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Mori

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(54) **HOLE PUNCHING APPARATUS**

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(73) Assignee: **Carl Manufacturing Co., Ltd.**, Tokyo (JP)

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(22) Filed: **Feb. 22, 1999**

(51) **Int. Cl.**[7] **B23B 51/00**
(52) **U.S. Cl.** **408/135**; 408/136; 408/204; 83/164; 83/629
(58) **Field of Search** 83/164, 629, 644, 83/126, 145, 685, 690; 408/136, 135, 204, 205, 207, 67, 87, 206

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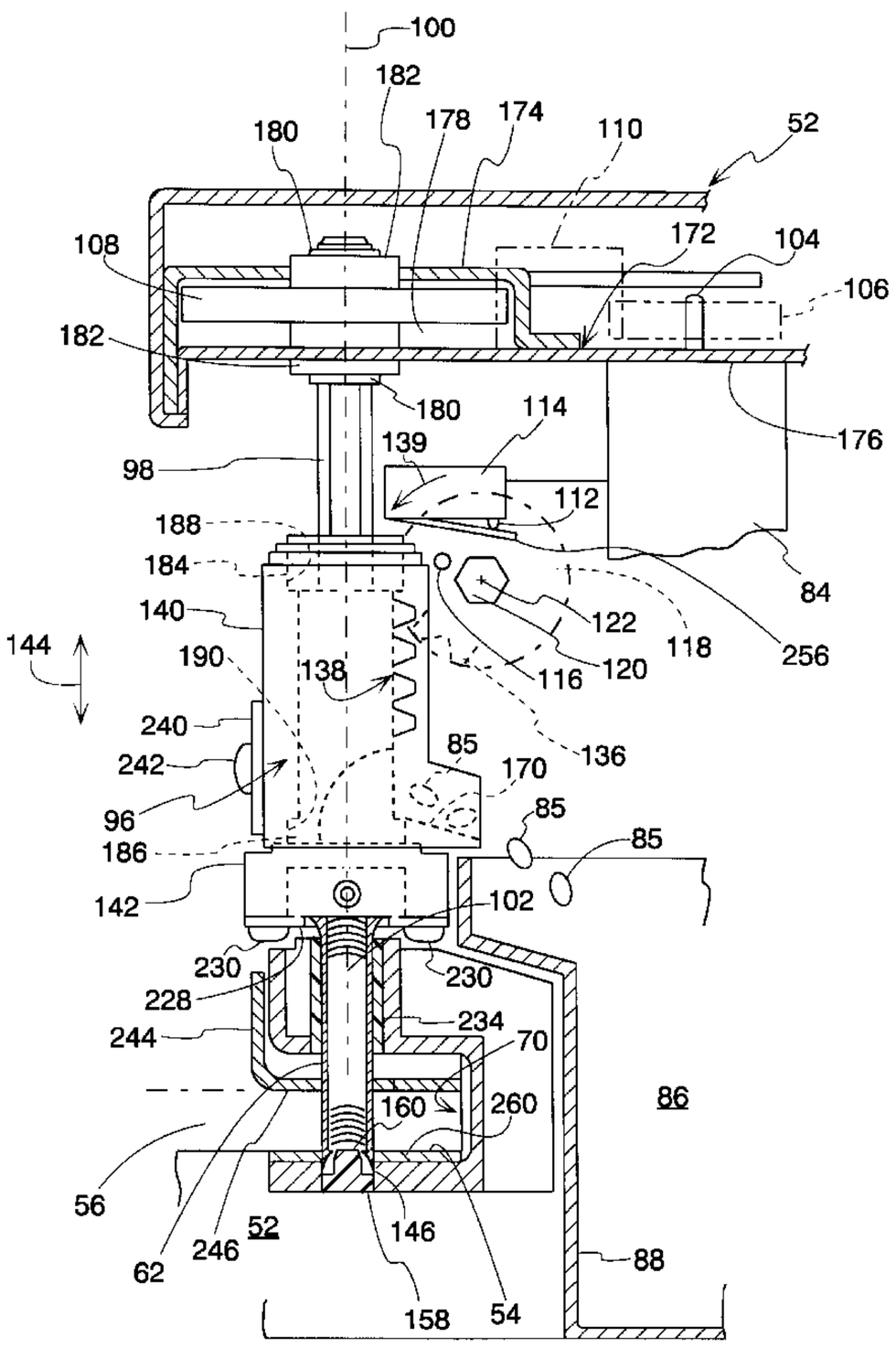
(57) **ABSTRACT**

A hole punching apparatus having a frame, a blade having a tubular cutting edge and a cavity, and a projection on the frame. The blade is movable relative to the frame between a retracted position and a cutting position. The projection moves into the blade cavity as the blade moves from the retracted position into the cutting position.

18 Claims, 10 Drawing Sheets



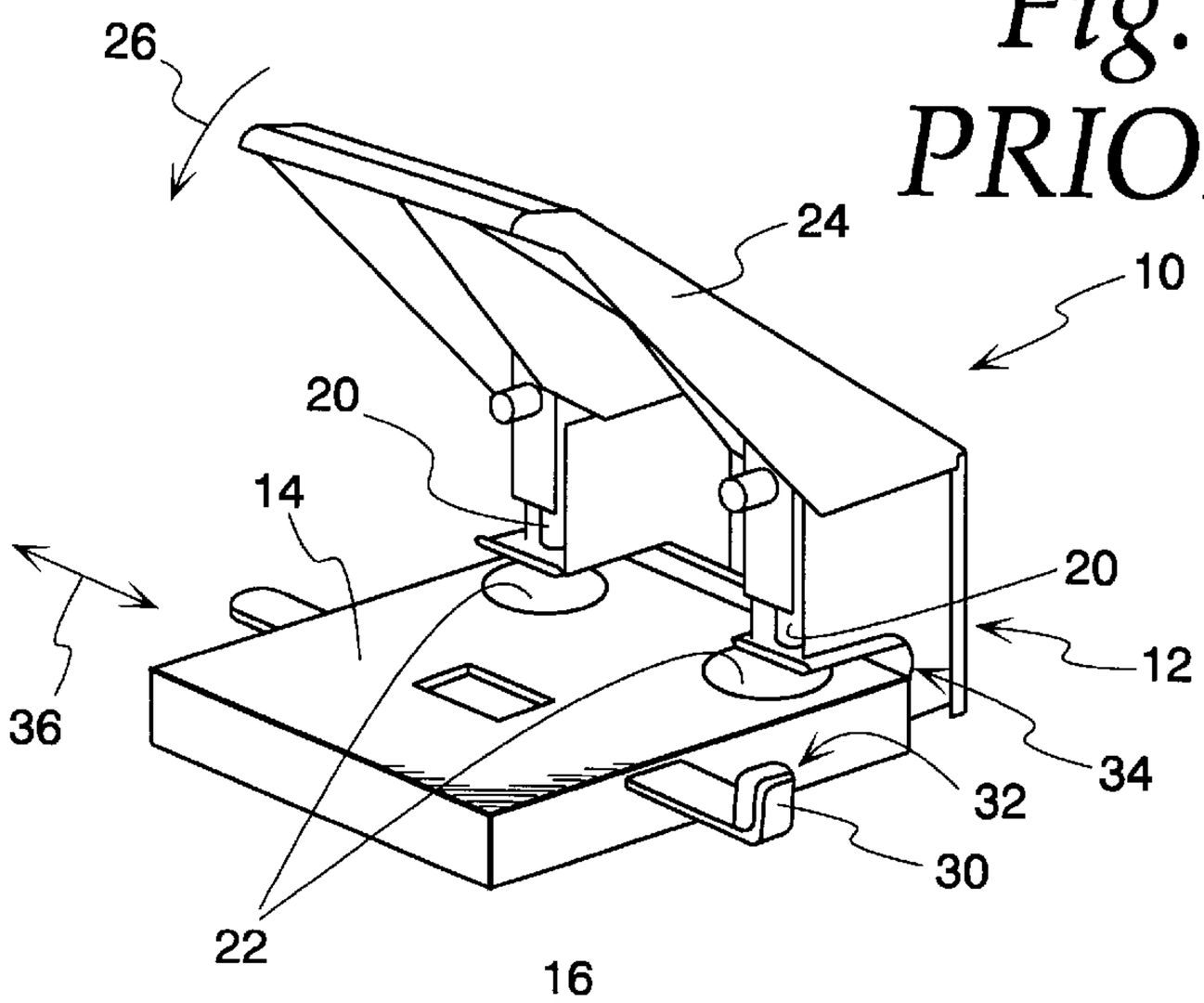


Fig. 1
PRIOR ART

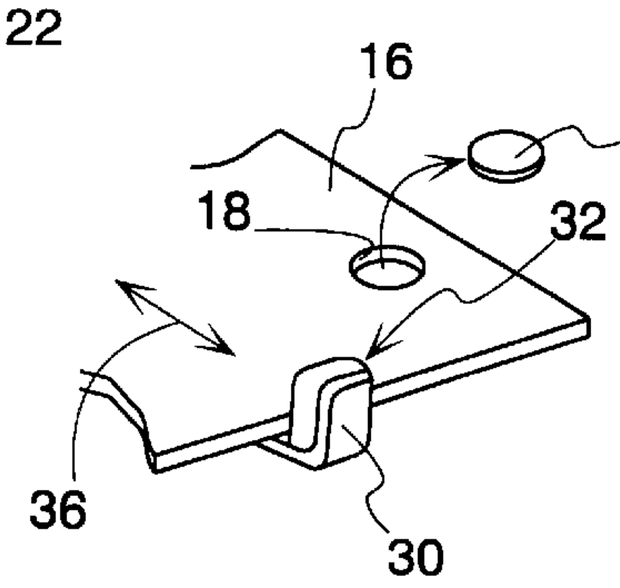


Fig. 4
PRIOR ART

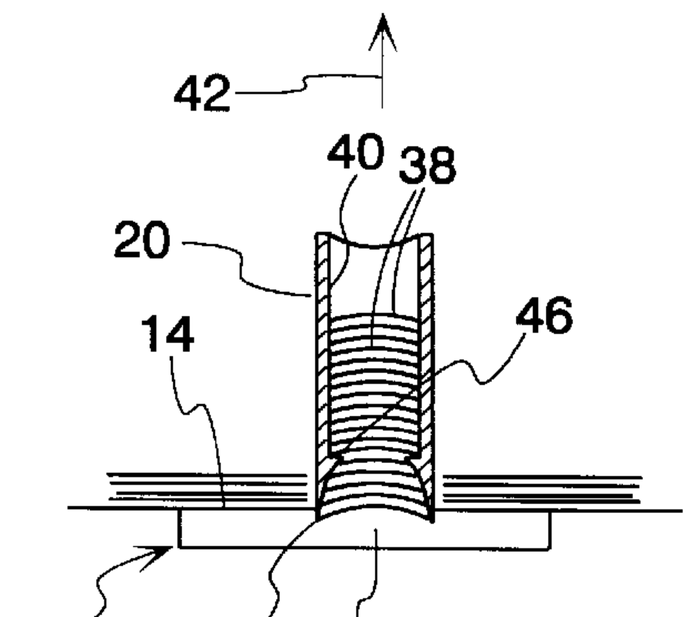


Fig. 2
PRIOR ART

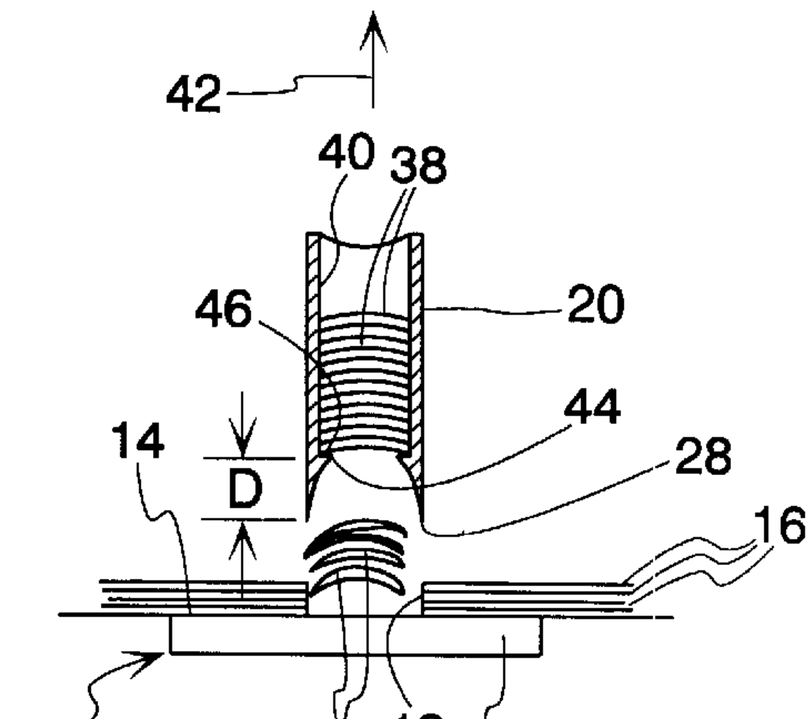


Fig. 3
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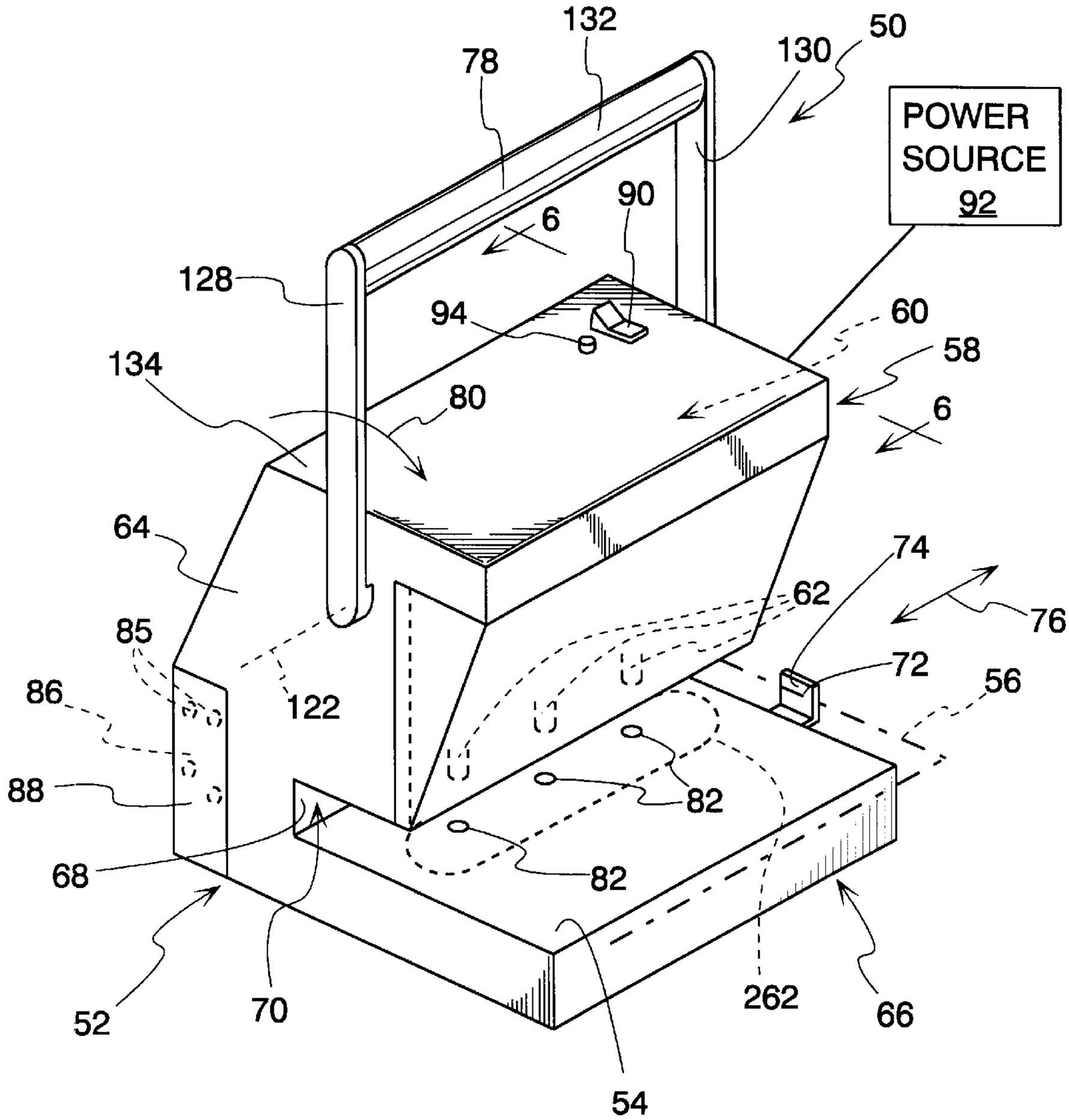
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Fig. 5

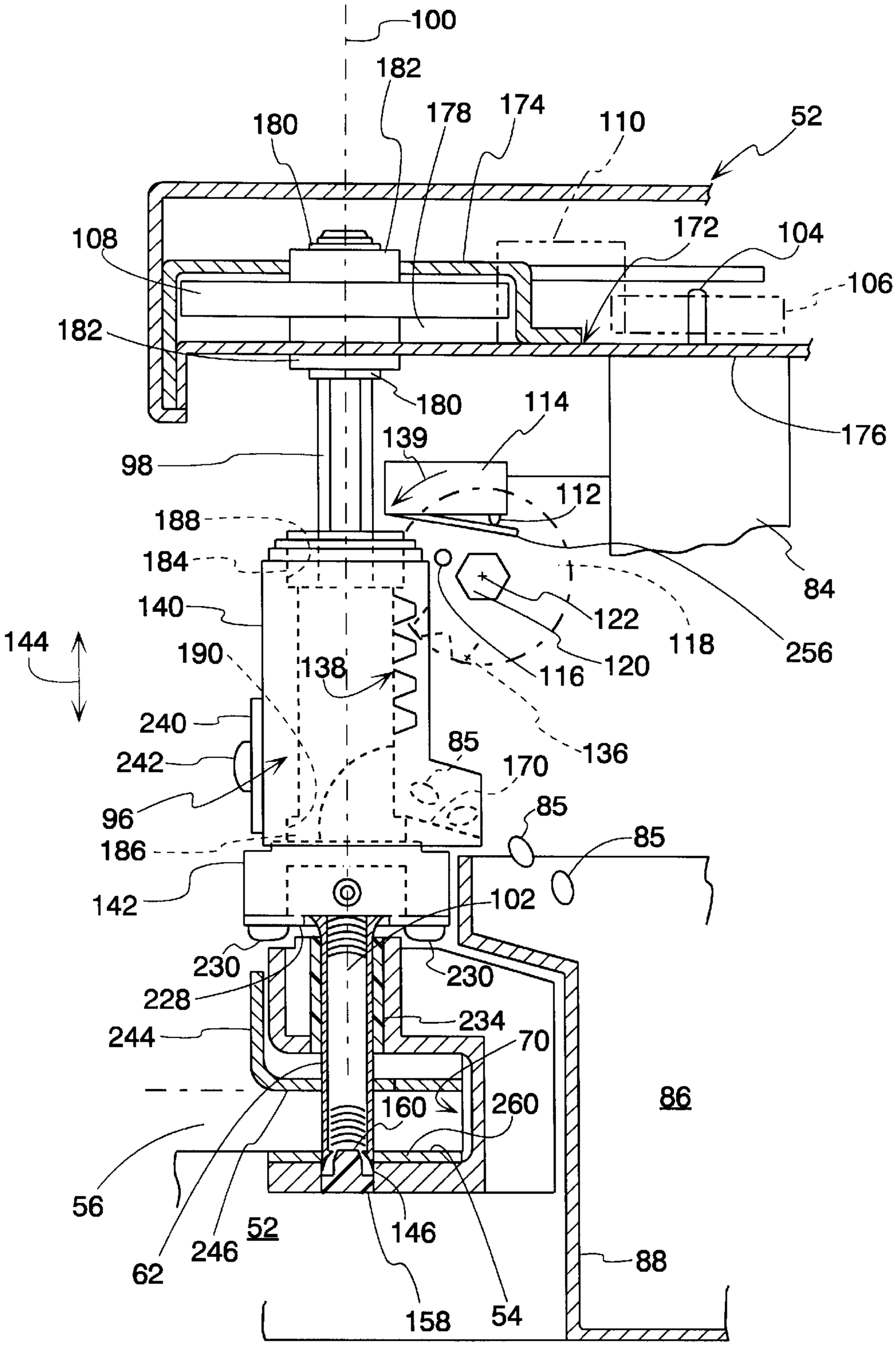
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Fig. 6

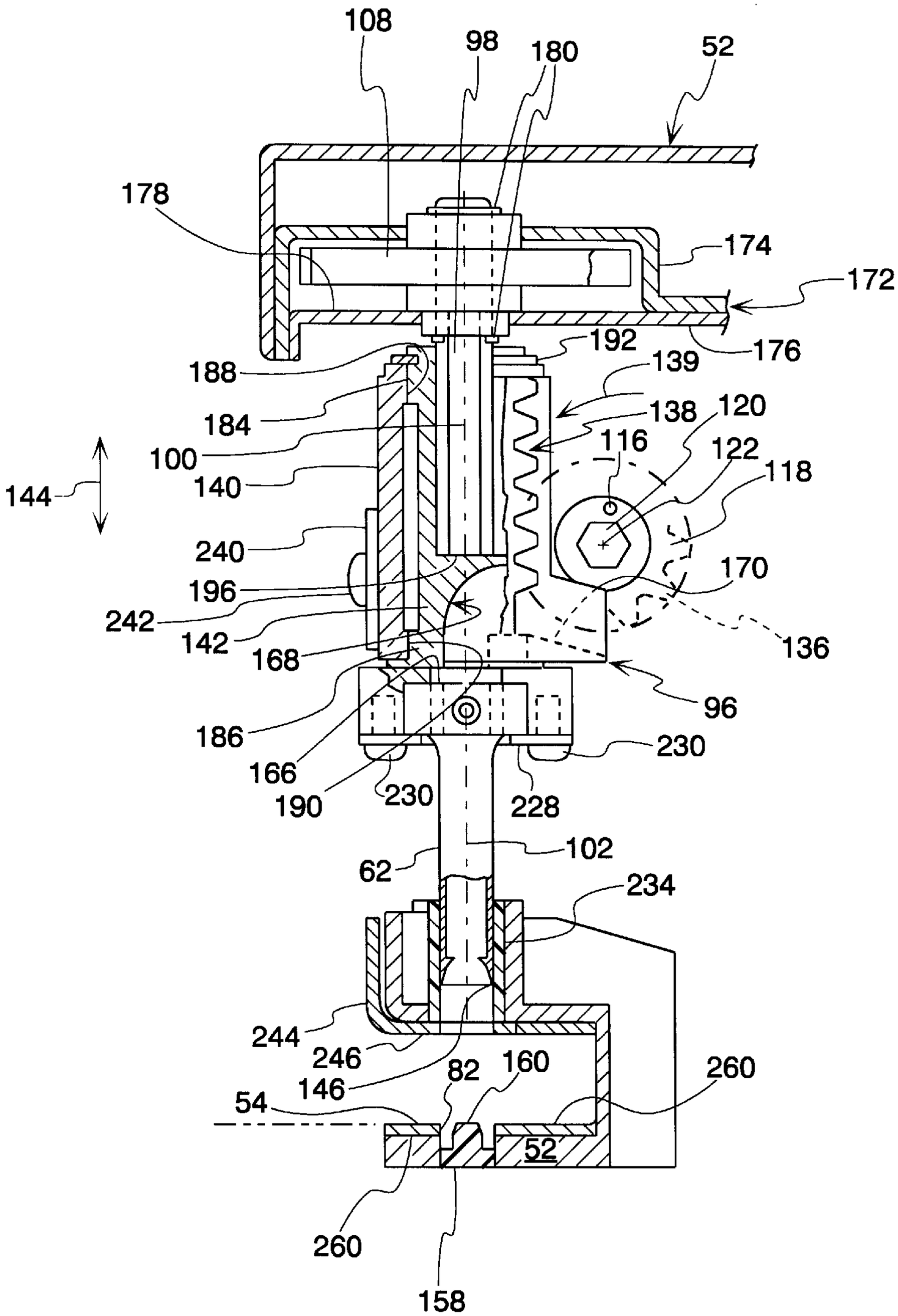
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Fig. 7

Fig. 8

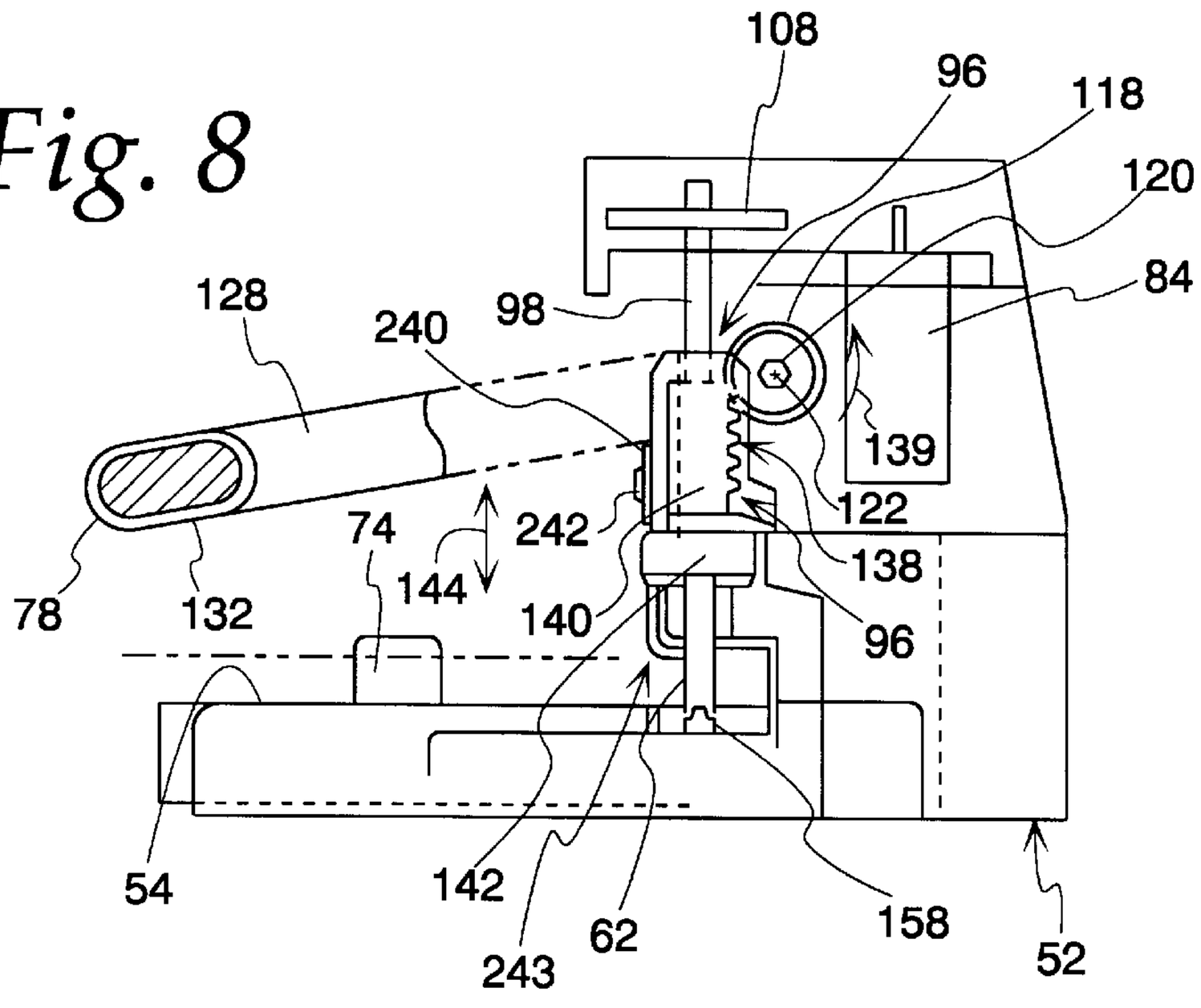
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Fig. 9

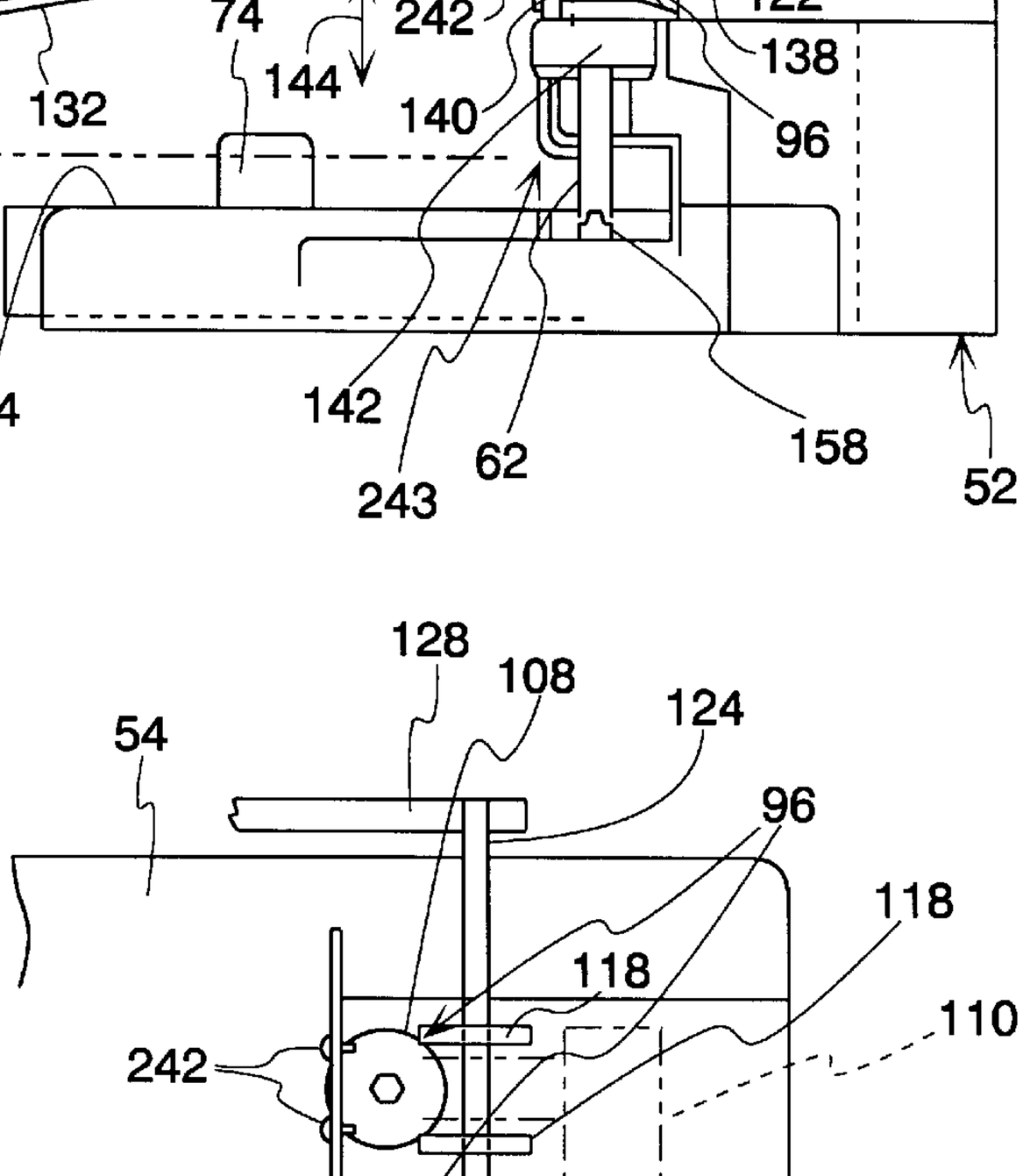
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Fig. 10

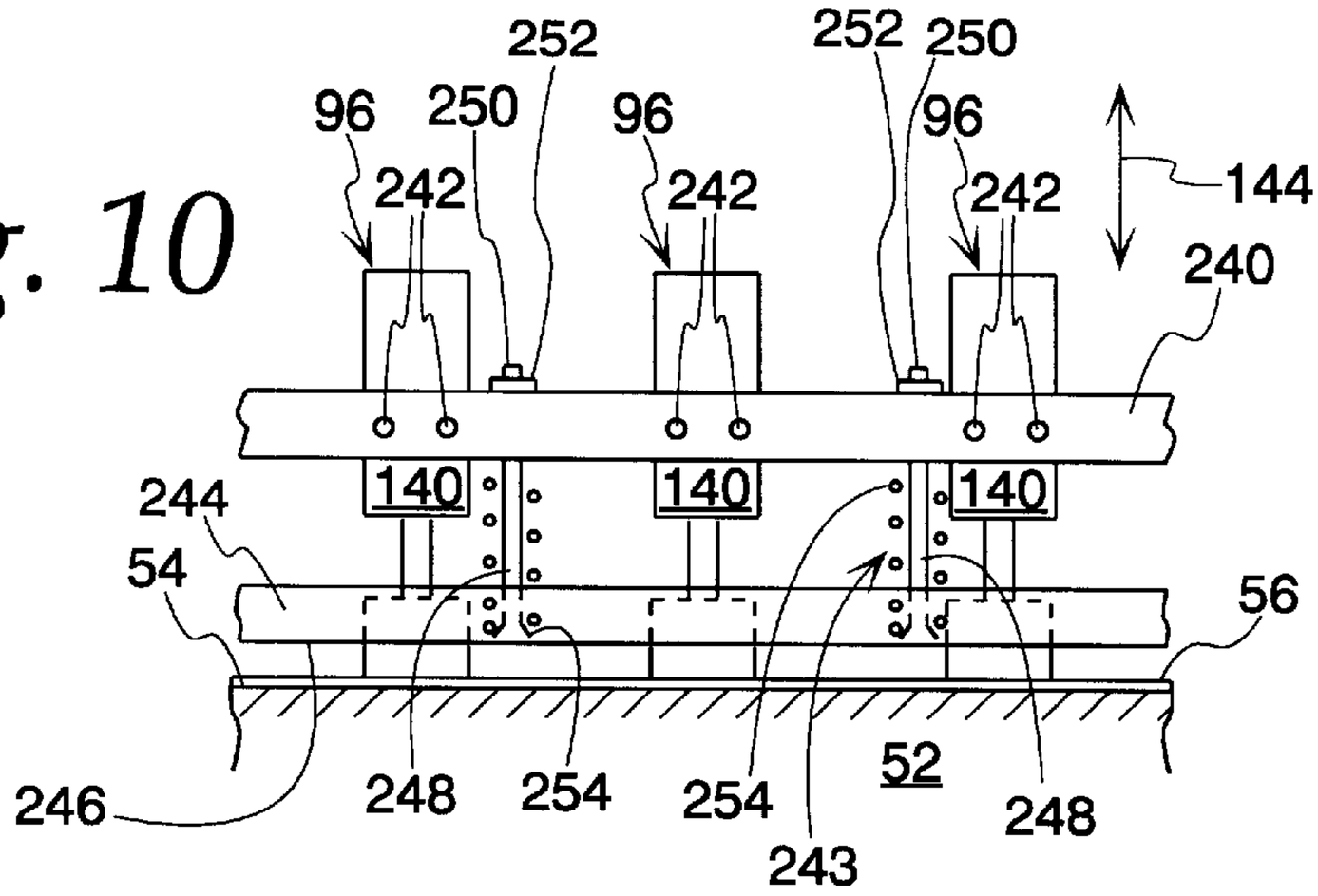


Fig. 11

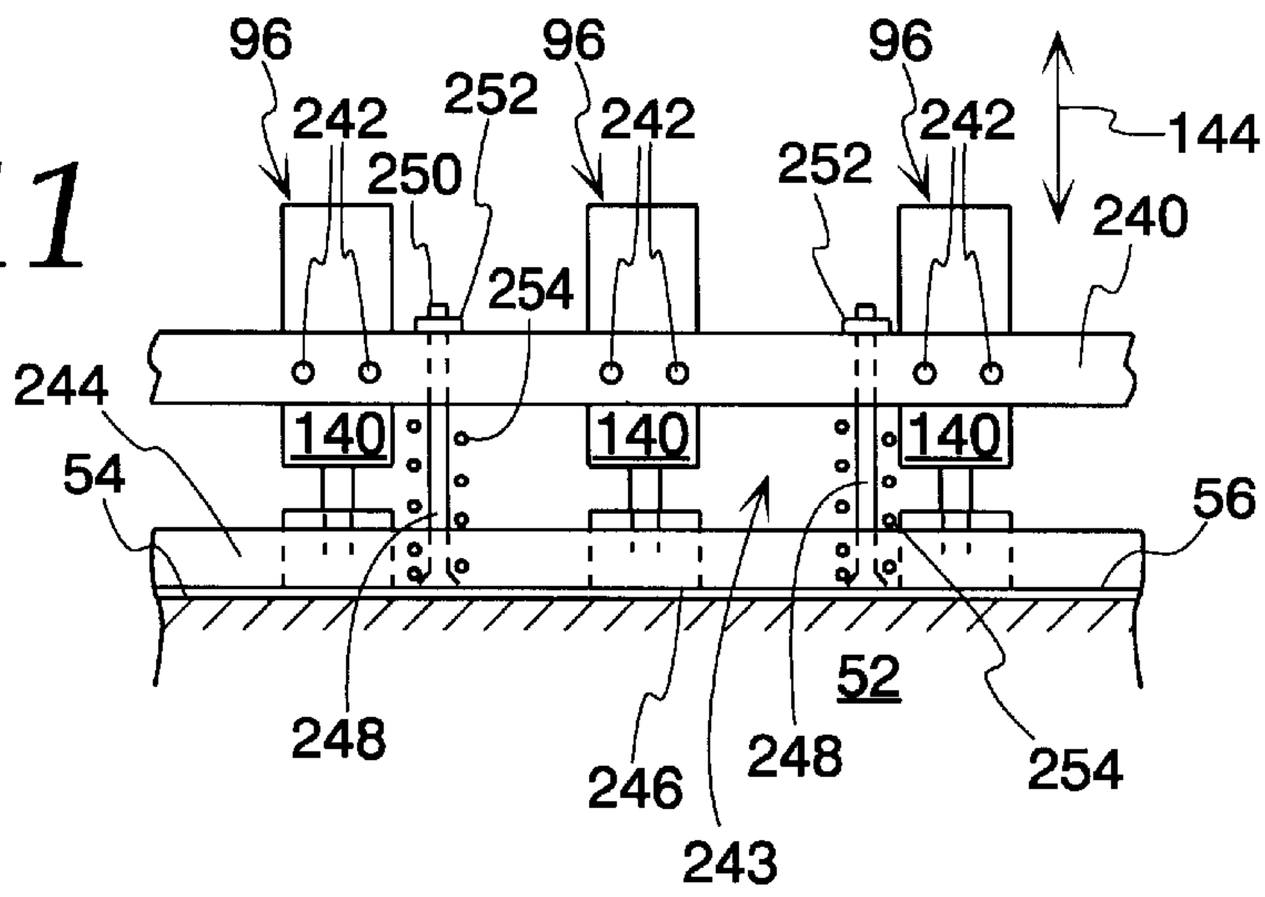
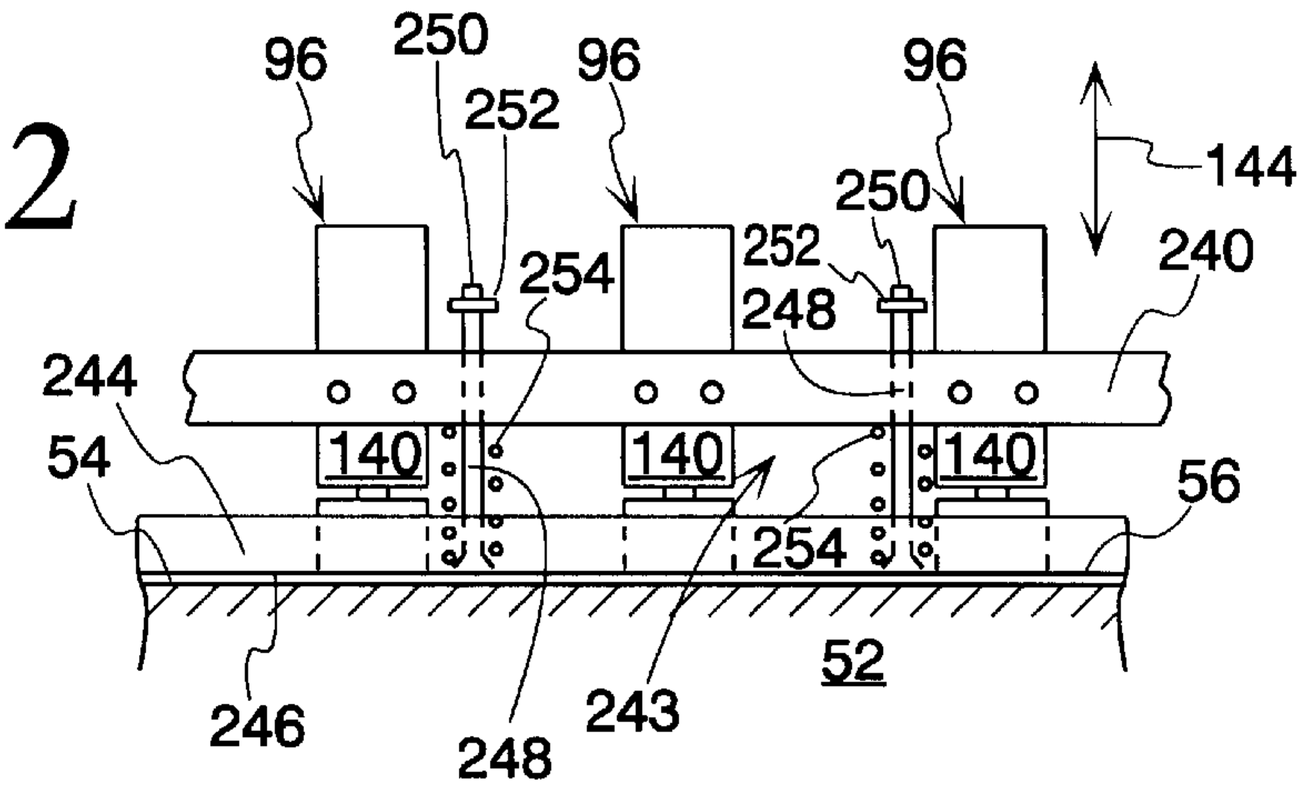


Fig. 12



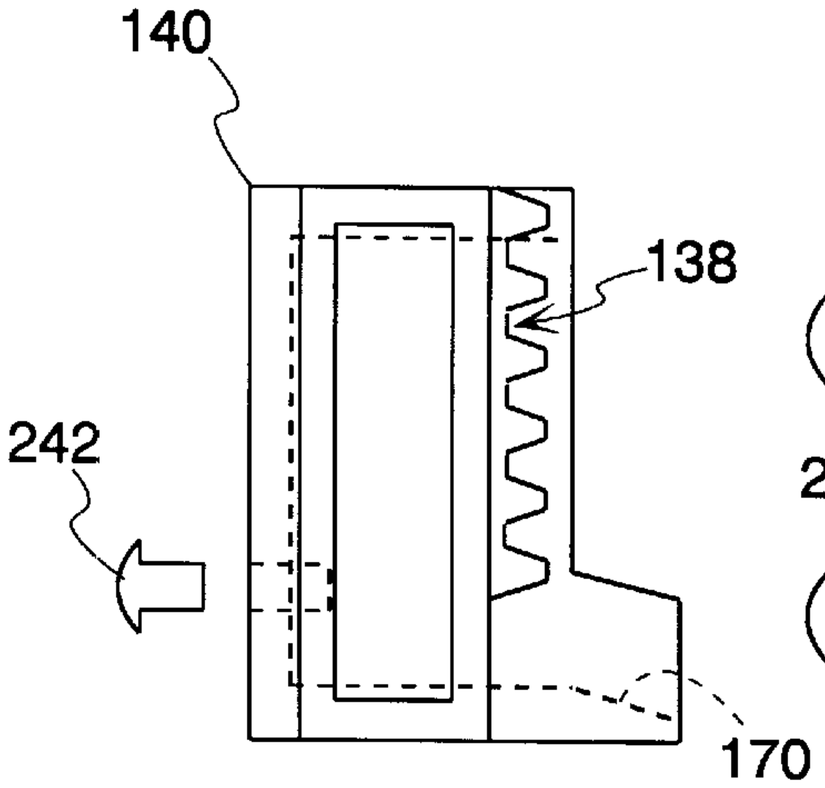


Fig. 13

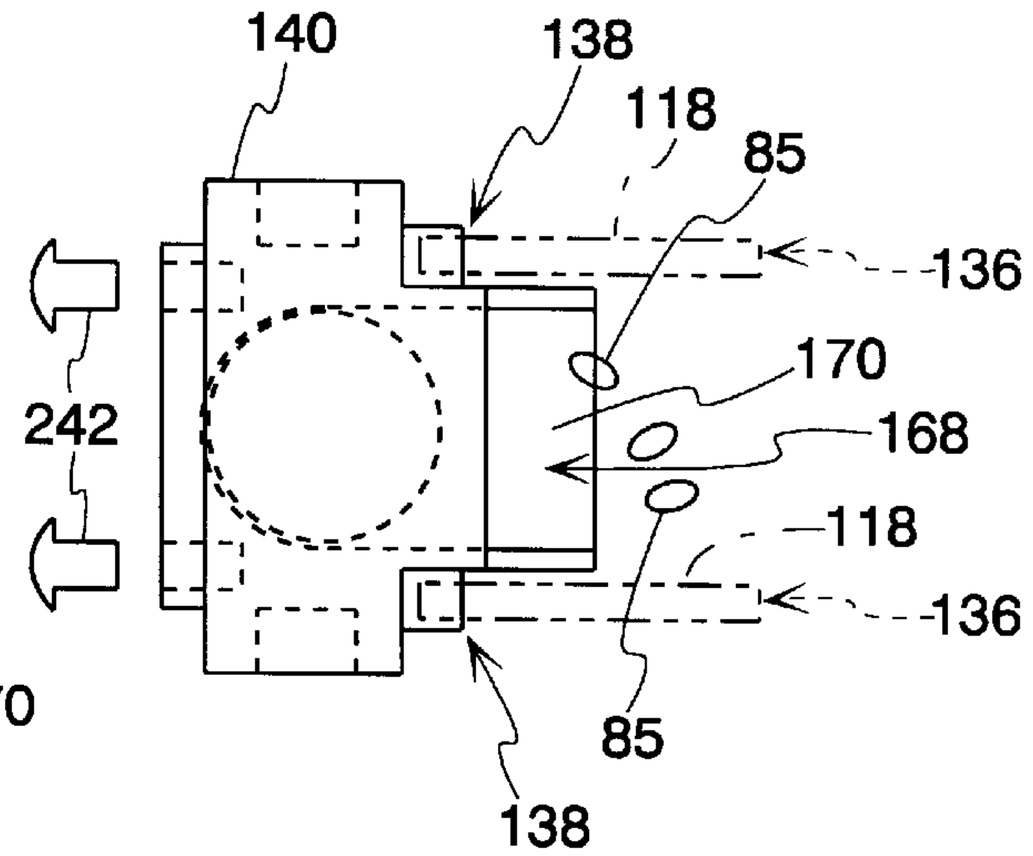


Fig. 14

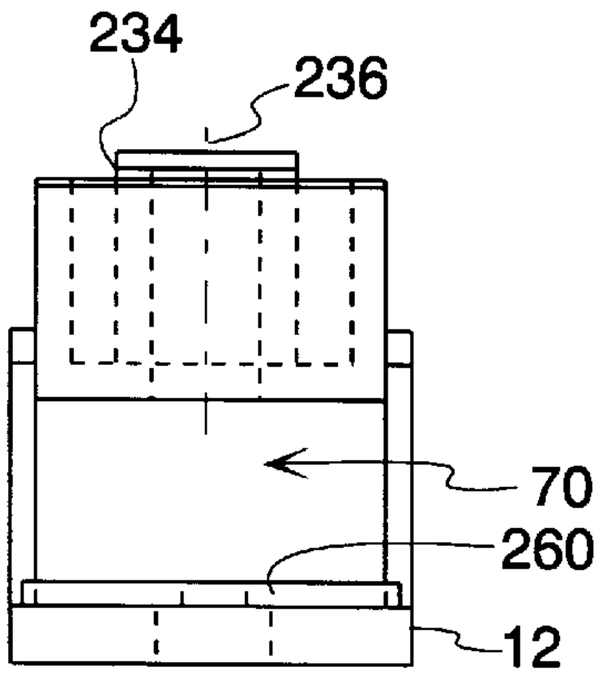


Fig. 15

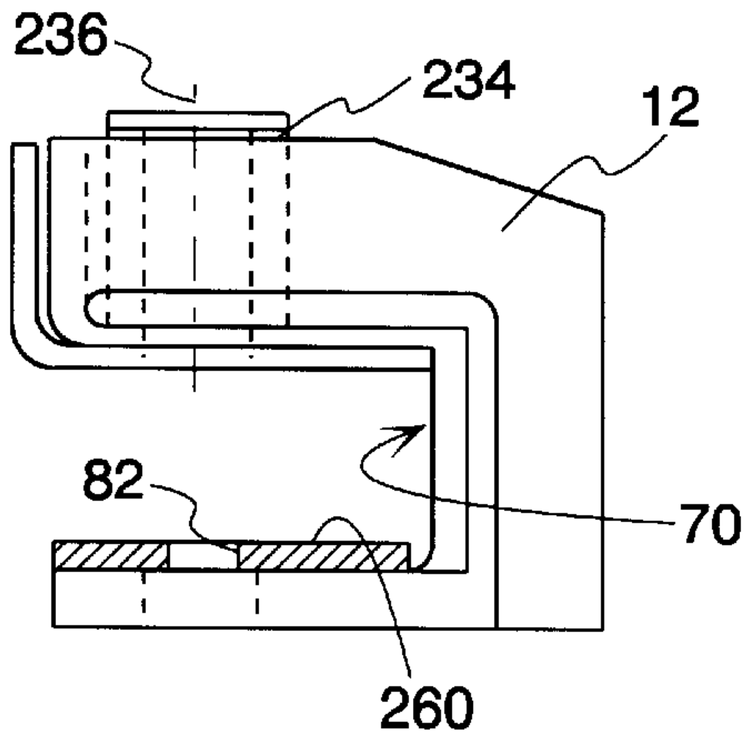
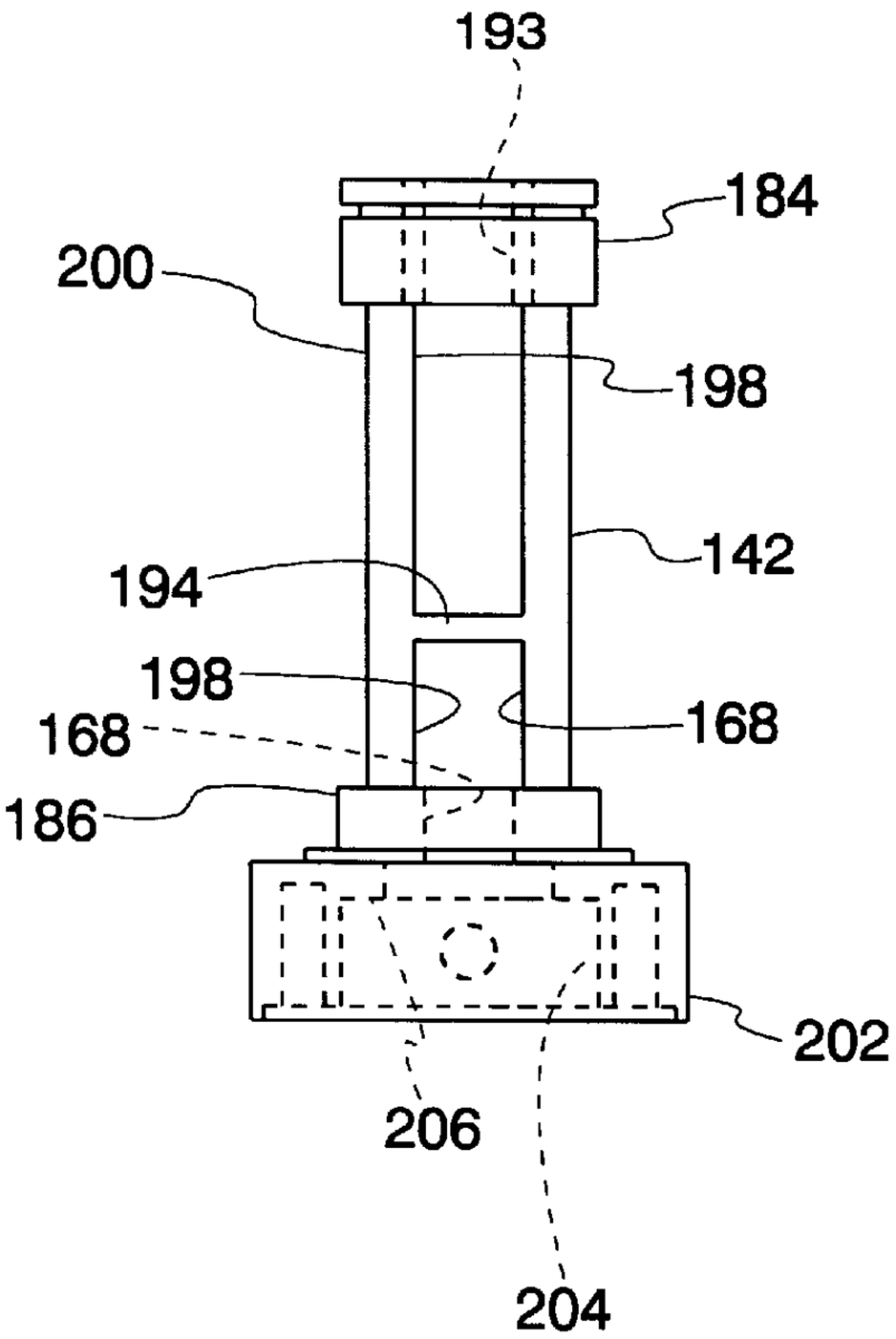


Fig. 16



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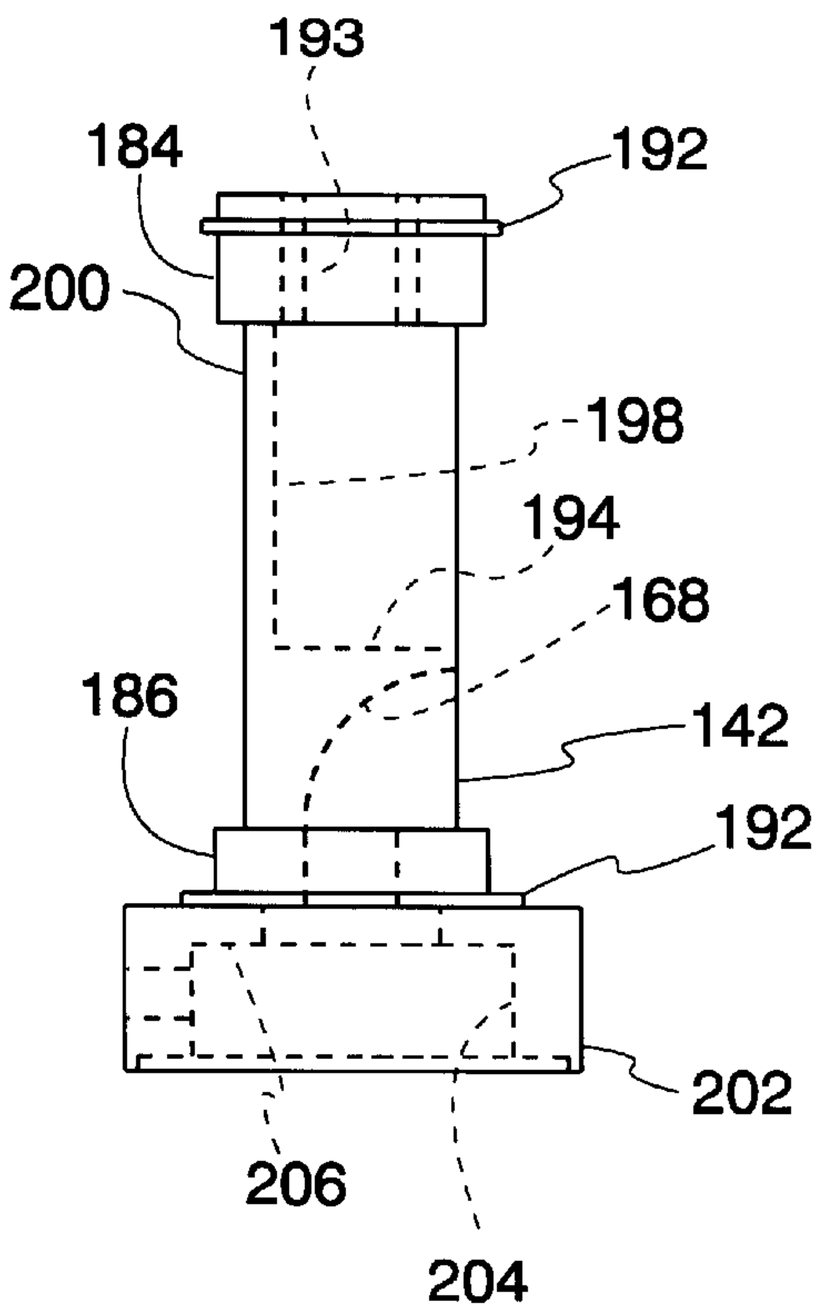

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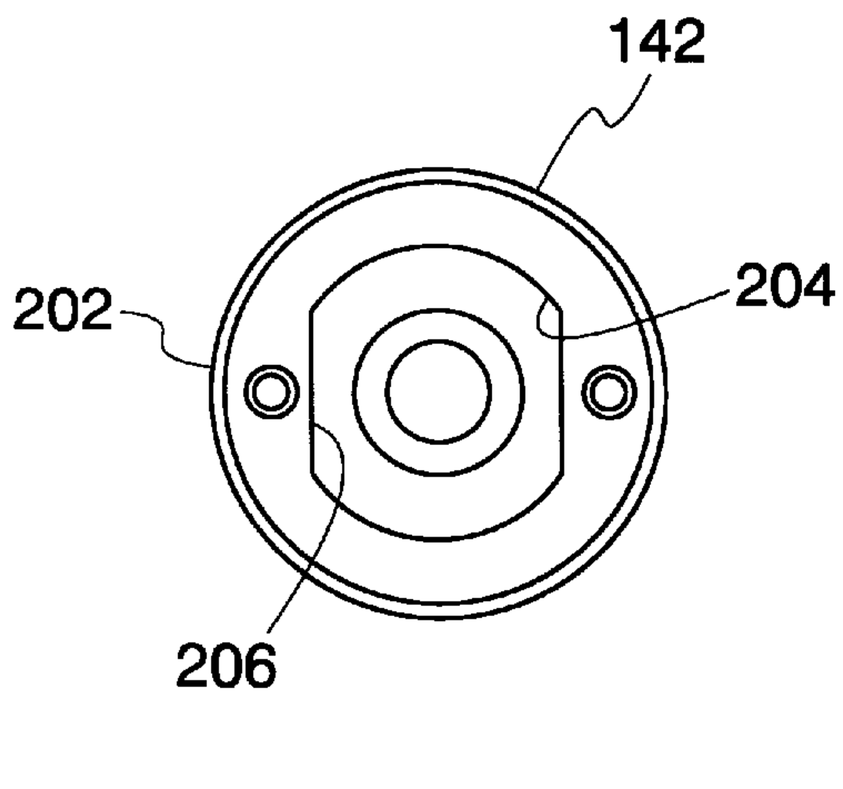

Fig. 19

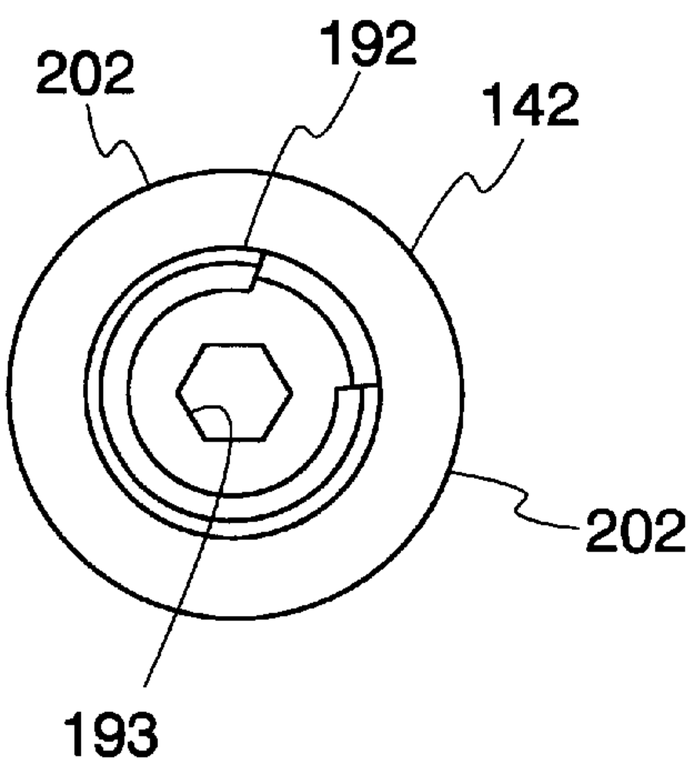

Fig. 20

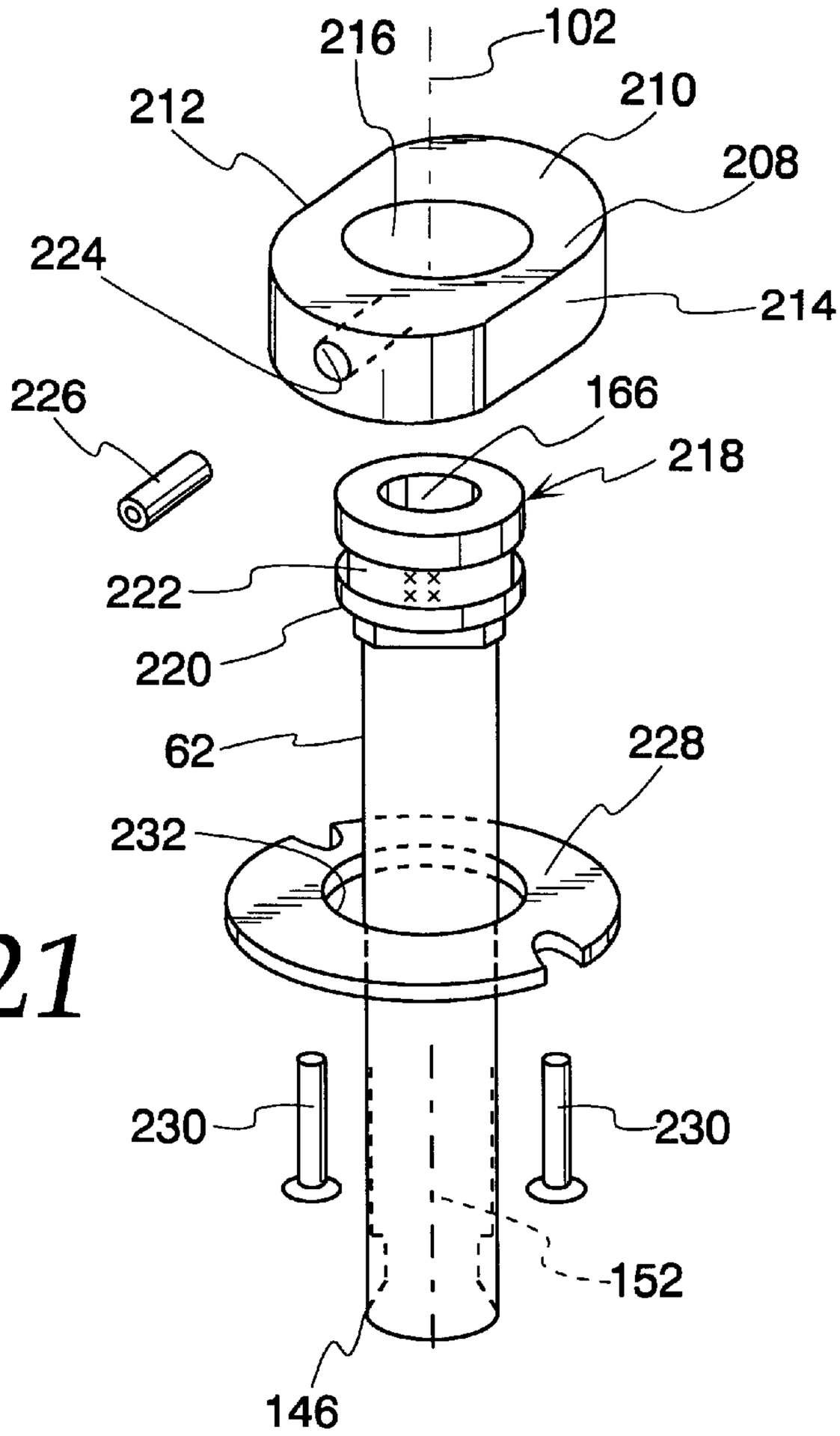
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Fig. 21

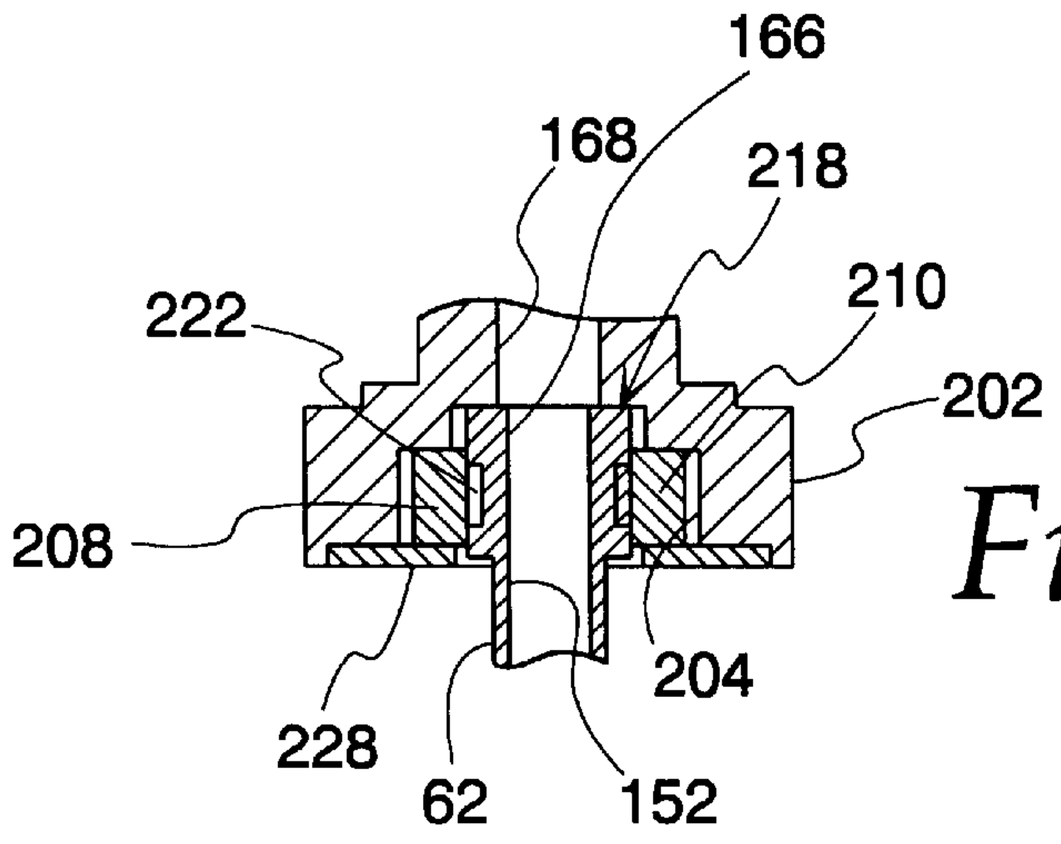
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Fig. 22

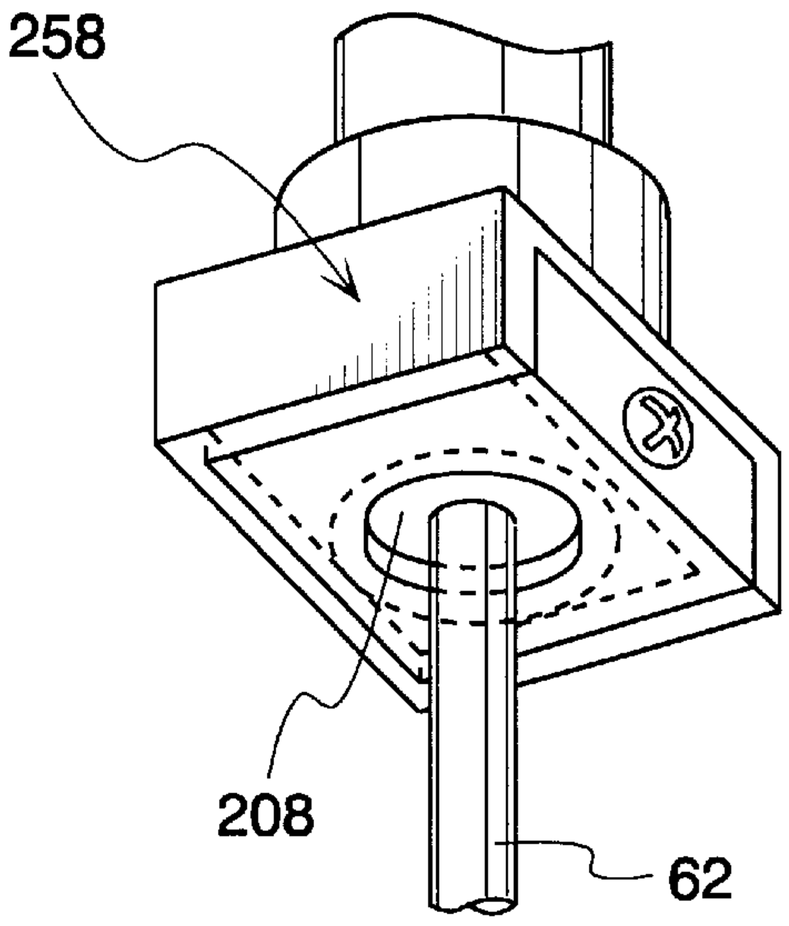

Fig. 23

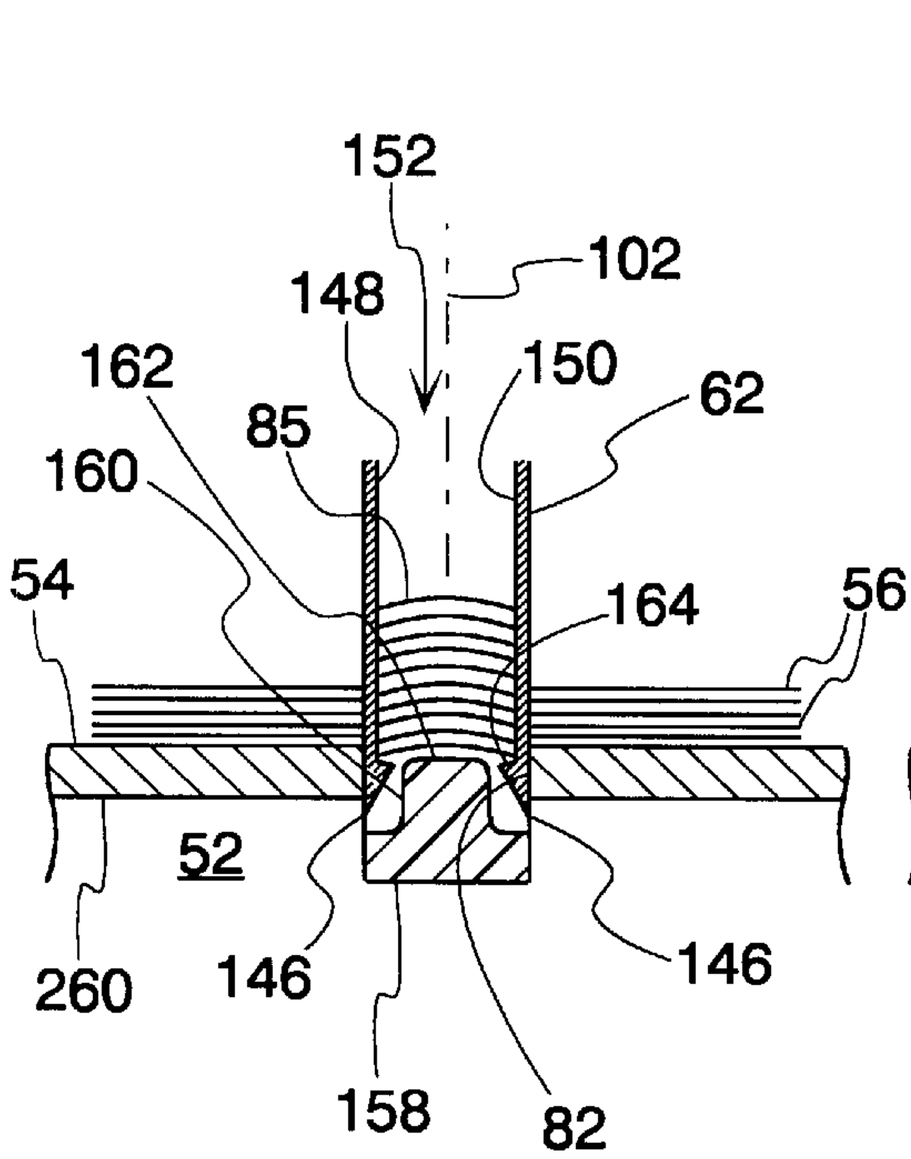

Fig. 24

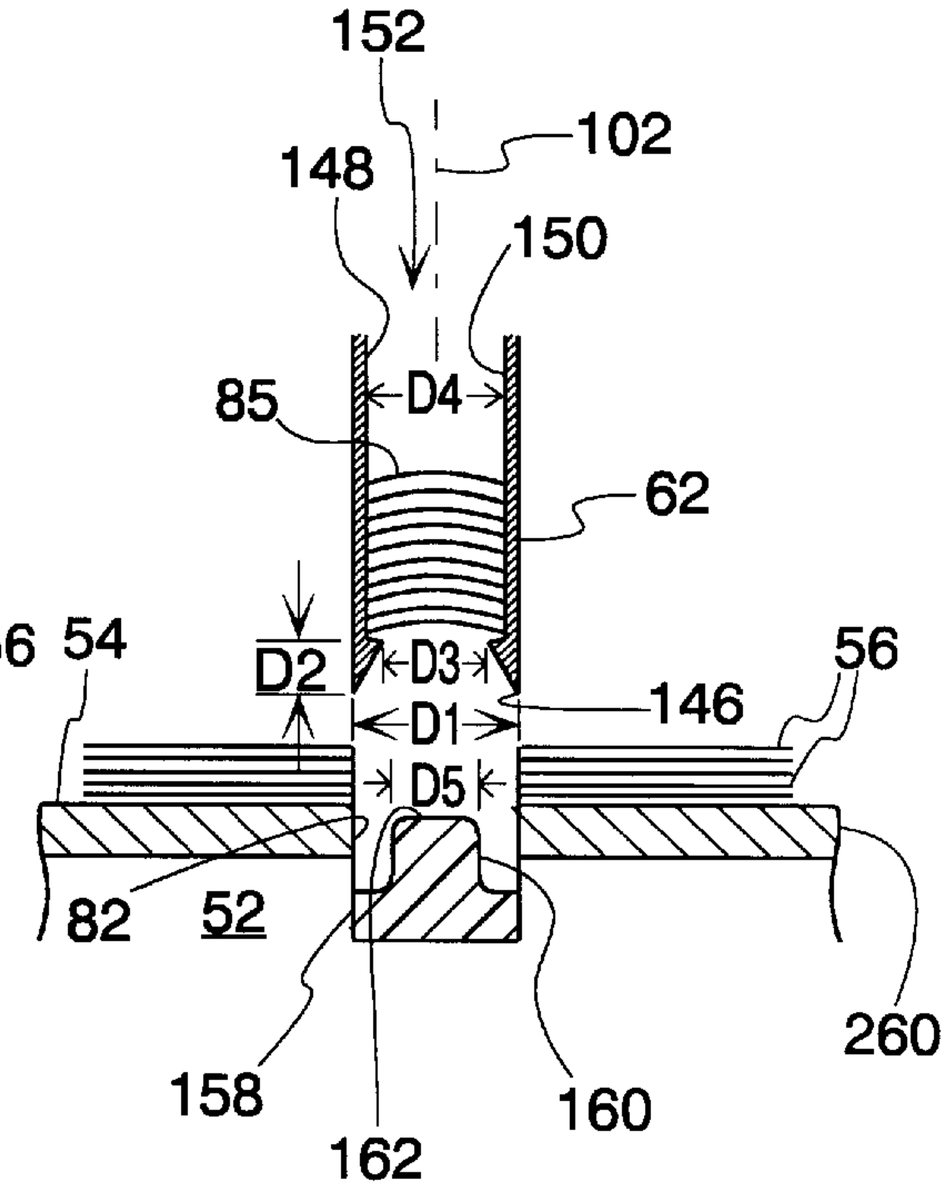

Fig. 25

HOLE PUNCHING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for punching holes in sheet material, such as paper.

2. Background of Art

It is common to bind multiple sheets of material, such as paper, using fasteners such as rings, string, metal clasps, etc. Holes are normally pre-punched in the sheet material to accept these fasteners.

One conventional apparatus for pre-punching holes in sheet material is shown at **10** in FIGS. **1–4** herein. The hole punching apparatus **10** consists of a frame **12** defining an upwardly facing, flat support surface **14** for multiple pieces of sheet material **16** into which holes **18** are punched. The frame **12** supports two, tubular, cutting blades **20** for movement relative to the frame **12** between a retracted position, as shown in FIG. **3**, and a cutting position, as shown in FIG. **2**. The frame **12** has two plastic backing elements **22**, provided one each beneath the cutting blades **20**. A handle **24** is mounted on the frame **12** and is repositionable from a normal position, shown in FIG. **1**, to an actuated position, by pivoting movement of the handle **24** in the direction of the arrow **26** to thereby reposition the cutting blades **20** from the retracted position into the cutting position. In so doing, an annular cutting edge **28**, at the free end of each cutting blade **20**, is driven through either a single piece of sheet material **16** or through stacked pieces of sheet material **16** to against the plastic backing element **22**. The frame **12** supports a guide element **30** with an upturned end **32** which is abuttable to an edge of the sheet material **16** facially abutted to the support surface **14** to predetermine the position of the sheet material **16** relative to the cutting blades **20** for consistent location of the holes **18**.

In a typical cutting operation, the piece or pieces of sheet material **16** are placed against the support surface **14** and shifted into a throat portion defined by the frame at **34** and at the same time abutted to the upturned end **32** of the guide element **30**. The guide element **30** can be appropriately repositioned by movement in the line of the double-headed arrow **36** to cause the desired hole locations on the sheet material **16** to be aligned precisely beneath the cutting blades **20**. The handle **24** is then grasped and pivoted in the direction of the arrow **26**, whereupon the cutting edges **28** on the cutting blades **20** engage and penetrate through the sheet material **16** so as to form, in this case, circular cut-outs **38** therefrom. As the cutting edges **28** bear on the backing elements **22**, the bottommost piece of sheet material **16** is penetrated fully through by the cutting edges **28**.

The cutting blades **20** each have an internal cavity **40** into which the cut-outs **38** are pressed during a punching operation. Each cavity **40** has a cross-sectional area that progressively decreases in diameter moving away from the cutting edge **28** a distance D at which point the cavity **40** has its smallest diameter and area. The diameter of the cavity **40** increases beyond the distance D to a diameter slightly smaller than the diameter of the cut-outs **38** so that the cut-outs **38** become slightly compressed. The snugly held cut-outs **38** are allowed to slide within the cavity upwardly, i.e. in the direction of the arrow **42**. As each cutting blade **20** moves from the retracted position into the cutting position, the formed cut-outs **38** become squeezed progressively as they move the distance D from the cutting edge **28** through a neck **44** at the distance D. An annular ledge **46** at the neck

44 abuts to, and thereby resists downward passage of, the cut-outs **38** that have moved to thereabove.

Systems, such as that shown in FIGS. **1–4**, may have a number of drawbacks. First of all, a substantial force may be required on the handle **24** to direct the cutting blades **20** fully through a stack of sheet material **16**. As the cut-outs **38** accumulate in the cavities **40**, the accumulating cut-outs **38** progressively increase the resistance to downward movement of the cutting blades **20**.

Another problem that may be encountered is that the cut-outs **38** that do not travel upwardly to beyond the necks **44** tend to spring out when the cutting blades **20** are moved back towards the retracted position. This may result in the cut-outs **38** having to be manually removed from the holes **18** in the sheet material **16** and/or cleaned up in the area surrounding the hole punching apparatus **10**.

In order to precisely form the holes **18**, and to do so with minimal effort, it is necessary that the cutting edges **28** on the cutting blades **20** remain sharp. In the event that the cutting edges **28** become dull, it is desirable to be able to change the cutting blades **20**, rather than replace the entire hole punching apparatus **10**. Some hole punching apparatus, similar to that shown at **10** in FIGS. **1–4**, do not lend themselves to facilitated replacement of the cutting blades **20**.

SUMMARY OF THE INVENTION

The invention is directed to a hole punching apparatus having a frame, a blade having a tubular cutting edge and a cavity, and a projection on the frame. The blade is movable relative to the frame between a retracted position and a cutting position. The projection moves into the blade cavity as the blade moves from the retracted position into the cutting position.

With the above construction, the projection can move cut-outs formed in a punching operation sufficiently into the cavity that they do not escape as the blade is moved back into the retracted position.

The hole punching apparatus may further have a drive for rotating the cutting edge around a first axis as the blade moves from the retracted position into the cutting position.

By rotating the cutting edge, cutting of the material in which a hole is to be formed is effected not only by pressure applied in moving the blade towards the cutting position, but also by the rotary movement of the cutting edge. This may reduce the amount of force required to be applied to the blade in moving the blade from the retracted position into the cutting position.

In one form, the cavity has first and second ends spaced along the first axis, with the cutting edge being at the first end of the cavity. The cavity has a diameter taken transversely to the first axis. The diameter of the cavity is non-uniform along the first axis.

In one form, the diameter of the cavity decreases from the cutting edge up to a first predetermined axial distance from the cutting edge towards the second end of the cavity and increases from the first predetermined distance towards the second end of the cavity. The projection extends into the cavity at least the predetermined axial distance from the cutting edge.

The blade may be movable substantially parallel to the first axis between the retracted and cutting positions.

A handle may be provided that is movable relative to the frame between a normal position and an actuated position. The blade is movable from the retracted position into the

cutting position as an incident of the handle moving from the normal position into the actuated position.

The handle may be pivotable about an axis as the handle moves between the normal and actuated positions.

The drive may include a drive motor for rotating the cutting edge around a first axis as the blade moves from the retracted position towards the cutting position. A switch may be provided that is placeable selectively in a) an on state to cause activation of the drive motor, and b) an off state to cause deactivation of the drive motor. The switch is moved from the off state into the on state as an incident of the handle moving from the normal position into the actuated position.

The hole punching apparatus may include a blade moving assembly and an adaptor for connecting the blade to the blade moving assembly. The blade moving assembly has a blade holder and a guide case. The blade moving assembly is translatable substantially parallel to the first axis between first and second positions as an incident of which the blade moves from the retracted position into the cutting position, and the blade holder is rotatable relative to the blade moving assembly around the first axis.

The blade may be loosely held by the blade moving assembly so that the blade can be shifted at least transversely to the first axis relative to the blade moving assembly.

The blade moving assembly may be movable from the first position into the second position as an incident of the handle moving from the normal position into the actuated position. The hole punching apparatus may further have a first set of gear teeth which are movable by the handle and a second set of gear teeth on the guide case which cooperate with the first set of gear teeth to cause the blade moving assembly to move from the first position into the second position as an incident of the handle moving from the normal position into the actuated position.

The first set of gear teeth may pivot with the handle about the second axis.

The hole punching apparatus may further include an actuator element which follows pivoting movement of the handle and causes the switch to be changed from the off state into the on state as an incident of the handle moving from the normal position into the actuated position.

A guide bushing may be provided on the frame to guide the blade from the retracted position into the cutting position.

The drive may include a shaft which is rotatable around the first axis, with the shaft being rotatable relative to the guide case around the first axis.

The shaft may be keyed to the blade holder so that the shaft drives the blade holder in rotation around the first axis.

In one form, there is a receptacle for material punched out by the hole punching apparatus on the frame. A passageway is defined through the blade holder and guide case. Material punched out by the hole punching apparatus is capable of communicating through the blade cavity to the passageway and through the passageway to the receptacle for accumulation therein. Provision may be made to empty cut-outs in the receptacle when desired.

In one form, the frame defines a surface to support material on which a hole punching operation is to be performed. The hole punching apparatus may include a pressing assembly which is normally biasably urged away from the support surface. The pressing assembly has a pressing surface which is moved towards the support surface to captively hold material against the support surface as an incident of the blade moving from the retracted position into the cutting position.

The hole punching apparatus may further have a second blade with a second tubular cutting edge and a second cavity. The second blade is movable relative to the frame between a retracted position and a cutting position. A second projection on the frame moves into the second blade cavity as the second blade moves from the retracted position for the second blade into the cutting position for the second blade. The second blade is movable from the retracted position for the second cutting blade into the cutting position for the second blade as an incident of the handle moving from the normal position into the actuated position.

The invention is also directed to a hole punching apparatus having a frame, a blade having a tubular cutting edge and a cavity, and a drive motor. The blade is movable relative to the frame between a retracted position and a cutting position. The drive motor rotates the cutting edge around a first axis as the blade moves from the retracted position into the cutting position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a conventional hole punching apparatus;

FIG. **2** is an enlarged, fragmentary, partial cross-sectional view of a tubular cutting blade on the hole punching apparatus of FIG. **1** that is extended through several pieces of sheet material, supported on a surface of a frame, fully into a cutting position;

FIG. **3** is a view as in FIG. **2** with the cutting blade repositioned from the cutting position of FIG. **2** into a retracted position;

FIG. **4** is an enlarged, fragmentary, perspective view of a part of the hole punching apparatus of FIG. **1** and showing the relationship between a piece of sheet material and a guide element on the frame with a cutout having been formed in the piece of sheet material;

FIG. **5** is a perspective view of a hole punching apparatus, according to the present invention;

FIG. **6** is an enlarged, cross-sectional view of the hole punching apparatus taken along line **6**—**6** of FIG. **5** and with cutting blades thereon in a cutting position;

FIG. **7** is a view as in FIG. **6** with the cutting blades in a retracted position;

FIG. **8** is a partially schematic, side elevation view of the hole punching apparatus in FIG. **5**, partially in cross section and with the cutting blades thereon in the cutting position;

FIG. **9** is a schematic, fragmentary, plan view of the hole punching apparatus in FIG. **5**;

FIG. **10** is a schematic, fragmentary, front elevation view of the hole punching apparatus in FIG. **5** with the cutting blades thereon in a retracted position;

FIG. **11** is a view as in FIG. **10** with the cutting blades being moved towards the cutting position;

FIG. **12** is a view as in FIGS. **10** and **11** with the cutting blades moved fully into the cutting position;

FIG. **13** is an enlarged, side elevation view of a guide case which translates, one each, with a cutting blade between the retracted and cutting positions;

FIG. **14** is an enlarged, plan view of the guide case in FIG. **13**;

FIG. **15** is an enlarged, front elevation view of a guide subassembly on the frame of the hole punching apparatus of FIG. **5**;

FIG. **16** is an enlarged, side elevation view of the guide subassembly in FIG. **15** partially in cross section;

FIG. **17** is an enlarged, elevation view of a blade holder on the hole punching apparatus of FIG. **5**;

FIG. **18** is an enlarged, elevation view of the blade holder rotated through 90° around a vertical axis from the position shown in FIG. **17**;

FIG. **19** is an enlarged, bottom view of the blade holder in FIGS. **17** and **18**;

FIG. **20** is an enlarged, plan view of the blade holder in FIGS. **17** and **18**;

FIG. **21** is an enlarged, exploded, perspective view of a cutting blade on the hole punching apparatus of FIG. **5** and an adaptor system used to mount the cutting blade to the blade holder in FIGS. **17** and **18**;

FIG. **22** is an enlarged, fragmentary, cross-sectional view of the connection between the blade holder, cutting blade, and adaptor;

FIG. **23** is an enlarged, bottom, perspective view of the connection between a modified form of blade holder and cutting blade, according to the present invention;

FIG. **24** is an enlarged, fragmentary, cross-sectional view of the cutting blade on the inventive hole punching apparatus of FIG. **5** extended into the cutting position through several pieces of sheet material; and

FIG. **25** is a view as in FIG. **24** with the cutting blade moved from the cutting position into the retracted position after the completion of a hole punching operation.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to FIG. **5**, a hole punching apparatus, according to the present invention, is shown at **50**. The general operation of the hole punching apparatus **50** is as follows. The hole punching apparatus **50** has a frame **52** which defines a surface **54** for supporting one or more pieces of sheet material **56** through which holes are to be punched. The frame **52** has a housing **58** which defines an upper compartment **60** within which a mechanism for repositioning, in this case three, tubular cutting blades **62**. Any number of blades **62**, from one to in excess of three, could be provided. The compartment **60** is enclosed by a plastic or metal cover sheet **64** formed into the shape shown and extending downwardly to a base **66** on the frame **52** which defines the support surface **54**.

In operation, the pieces of sheet material **56** into which holes are to be punched are placed in a stack facially against the surface **54**. One edge of each piece of sheet material **56** is abutted to a forwardly facing wall **68** at the base of a throat **70** defined between the base **66** and upper compartment **60**. Consistent lateral positioning of the sheet material **56** relative to the cutting blades **62** is maintained by a guide element **72** having an upturned end **74**, to abut to an edge of each piece of sheet material **56**, that is transverse to the edges of the sheet material **56** abutted to the throat wall **68**. The guide element **72** is adjustable laterally along the base **66**, in the line indicated by the double-headed arrow **76**.

Once the sheet material **56** is properly situated on the support surface **54** of the base **66**, a handle **78** is moved from a normal position, shown in FIG. **5**, by pivoting in the direction of the arrow **80**, to an actuated position (FIG. **8**). This causes the cutting blades **62** to advance downwardly through the pieces of sheet material **56** and into openings **82** through the base surface **54**, whereupon the pieces of sheet material **56** are severed by each cutting blade **62**.

According to the invention, operation of the handle **78** not only translates the cutting blades **62** but activates a drive motor **84** (see FIGS. **6** and **8**) to cause each of the cutting blades **62** to rotate around a vertical axis. Return of the handle **78** from the actuated position to the normal position deactivates the motor **84**. Cut-outs **85** formed by the cutting blades **62** advance through the cutting blades **62** for accumulation in a receptacle **86** defined by the frame **52**. The receptacle **86** is defined by a container **88** that is separable to allow convenient disposal of the cut-outs **85**.

An external switch **90** is operable to selectively allow power to be supplied to the motor **84** from a power source **92** and to interrupt the supply of power from the power source **92** to the motor **84**. A re-settable breaker **94** is also provided on the frame **52**.

The details of the hole punching apparatus **50**, as described generally above, are described below with reference to FIGS. **5–25**. Each cutting blade **62** is mounted to a blade moving assembly **96** that depends from a shaft **98** which is driven in rotation through the motor **84** about a first, vertical axis **100** that is coincident with a central axis **102** of the tubular cutting blade **62**. The motor **84** has a shaft **104** which drives a pulley **106** in rotation. The pulley **106** drives pulleys **108**, attached one each to the shafts **98**, through a conventional speed reducer **110**.

The motor **84** is activated with a button **112** on a micro switch **114** extended as in FIG. **6**. Depression of the button **112** deactivates the motor **84**. The state of the switch **114** is changed by an actuating element **116** carried on a gear **118**, with there being two such gears **118** associated in laterally spaced relationship with each blade moving assembly **96**. The gears **118** are carried by a laterally extending shaft **120** which is guided for pivoting movement relative to the frame **52** around a laterally extending axis **122**. Opposite ends **124**, **126** of the shaft **120** project to externally of the frame **52**. The shaft ends **124**, **126** connect, one each, to elongate arms **128**, **130** defining the handle **78**. The elongate arms **128**, **130** are in turn connected to a gripping portion **132** so that the gripping portion **132** and elongate arms **128**, **130** cooperatively define a U shape. By grasping the gripping portion **132** of the handle **78**, the handle **78** can be pivoted in the direction of the arrow **80** in FIG. **5** to reposition the handle **78** from the normal position to the actuated position. The length of the arms **128**, **130** is selected so that the user's hand grasping the gripping portion **132** does not contact the upper surface **134** of the upper housing **58** as the handle **78** is moved into the actuated position. Pivoting of the handle **78** about the axis **122** pivots the shaft **120**, and the gears **118** thereon, around the axis **122**.

A first set of teeth **136** is provided in an annular arrangement on each gear **118**. The first set of teeth **136** on each gear **118** is in mesh with a second set of teeth **138** in a linear arrangement on the blade moving assembly **96**. By pivoting the handle **78** from the normal position of FIG. **5** towards the actuated position of FIG. **8**, the shaft **120** rotates in the direction of the arrow **139**, causing the blade moving assembly **96** to move from a first position, as shown in FIG. **7**, to a second position, as shown in FIG. **6**.

The blade moving assembly **96** consists of a guide case **140** on which the second set of teeth **138** are formed, and a blade holder **142** which is movable with the guide case **140** along the axis **100**, i.e. in the direction of the double-headed arrow **144**, and rotatable guidingly relative to the guide case **140** around the axis **100**. Through this arrangement, the blade holder **142**, and cutting blade **62** held thereby, can be rotated with the shaft **98** as the blade moving assembly **96** translates downwardly along the axis **100** in moving from the first position into the second position.

By rotating the cutting blade **62** as it is advanced against and through the sheet material **56** in which a hole is to be punched, piercing of the sheet material **56** is effected cooperatively by the rotary action of a free cutting edge **146** at the axial end of the cutting blade **62** and the axial pressure applied to the free cutting edge **146** through operation of the handle **78**. As a consequence, less force may be required to be applied to the handle **78** to sever the sheet material **56**.

As seen in FIGS. **24** and **25**, the cutting blade **62** is tubular, at least adjacent to cutting edge **146**, and preferably along the entire axial extent thereof. The cutting blade **62** has a tubular body **148** with axially spaced ends and an inside surface **150** defining a cavity **152** for the accumulation of cut-outs **85** separated from the sheet material **56**. The cavity **152** has a cross-sectional area taken transversely to the central axis **102** that is circular with a diameter D1. The cross-sectional area can be other than a circular shape without departing from the invention.

The cross-sectional area of the cavity **152** increases progressively axially away from the cutting edge **146** for a predetermined distance D2 at which point the cavity **152** has the smallest diameter D3. Beyond the distance D2 from the cutting edge **146**, the inside surface **150** has a substantially uniform diameter D4 that is slightly less than the diameter of the cut-outs **85**. With this arrangement, the cut-outs **85** are radially compressed progressively as they move the distance D2 through the cavity **150**, whereupon they are allowed to spring back to only a slightly deformed state beyond the distance D2 within the diameter D4. The cut-outs **85** thus become closely held but are slidable axially in a stacked relationship.

The frame openings **82** through the support surface **54** closely receive the cutting edges **146**. An insert **158** made of plastic, or the like, is provided on the frame **52** within each opening **82** and has a projection **160** formed thereon and having a diameter D5 that is less than the diameter D3 of the cavity **152** at the distance D2 from the cutting edge **146**, i.e. where the diameter of the cavity **152** is the smallest. The projection **160** has an axial extent selected so that with the cutting blade **62** in the cutting position of FIG. **24**, the leading surface **162** of the projection **160** extends into the cavity **152** a distance slightly greater than the distance D2 so that the cut-outs **85** are pressed thereby into the larger diameter portion of the cavity **152** having the diameter D4. An annular, upwardly facing ledge **164** is defined at the distance D2 from the cutting edge **146**, with the ledge **164** preventing the cut-outs **85** that are substantially undeformed thereabove, from moving downwardly and escaping from the cavity **152**. The cut-outs **85** are consistently pressed by the projection **160** to a position wherein they are held by the ledge **164** as an incident of the cutting blade **62** moving from the retracted position of FIG. **25** into the cutting position of FIG. **24**.

As seen in FIGS. **6**, **7**, **21** and **22**, the cavity **152** extends over the full axial extent of each cutting blade **62**. Repeated hole punching operations cause cut-outs **85** to accumulate progressively in the cavity **152**. The cut-outs **85** eventually fill the cavity **152**, after which further punching operations cause the cut-outs **85** to be pressed from the open upper end **166** of the cutting blade **62** from where the cut-outs **85** are guided through a passageway **168**, defined cooperatively by the guide case **140** and blade holder **142**, to a ramp surface **170** on the guide case **140** (see also FIGS. **13** and **14**). The cut-outs **85** are guided by the ramp surface **170** under their own weight to the receptacle **86** for accumulation therein.

The mounting of the blade moving assemblies **96** will now be described in greater detail with reference to FIGS. **6**, **7**, **13**, **14** and **17–22**. Each blade moving assembly **96** is supported on one of the shafts **98**, which depends from a wall **172** on the frame **52**. The wall **172** has two layers **174**, **176** which are spaced so as to define a cavity **178** for the pulleys **108**. The shaft **98** extends through both layers **174**, **176** of the wall **172**. Clips **180** attach to the shaft **98** in grooves at locations above and below the wall **172** so that the wall **172** is captive between the clips **180** to maintain the vertical/axial location of the shaft **98** on the frame **52**. Bearings **182** facilitate smooth rotation of the shaft **98** around the axis **100** and relative to the frame wall **172**.

The blade holder **142** has radially enlarged, axially spaced, ends **184**, **186** which are guided for rotation against complementary surfaces **188**, **190** on the guide case **140**. Clips **192** are pressed into grooves at the ends **184**, **186** to maintain a substantially fixed axial relationship between the blade holder **142** and guide case **140**, while permitting the blade holder **142** to rotate relative to the guide case **140** around the axis **100**.

The blade holder **142** has a bore **193** that is complementary to the cross-sectional shape of the shaft **98**. In this embodiment, the shaft **98** and bore **193** have a hexagonal cross-sectional configuration. The bore **193** extends axially downwardly to a partition **194** on the blade holder **142** to which the shaft free end **196** abuts. An opening **198** is provided through a peripheral wall **200** on the blade holder **142**. The opening **198**, below the partition **194**, defines part of the passageway **168** for cut-outs **85** communicating from the cutting blade cavity **152** to the receptacle **86**.

At the blade holder end **186**, beneath the lower clip **192**, is a radially enlarged mounting portion **202**. The mounting portion **202** has a stepped bore **204** therethrough which defines a receptacle **206** for an adaptor **208**, through which the cutting blade **62** is operatively mounted to the blade holder **142**. The adaptor **208** has a generally oval body **210** with oppositely facing flats **212**, **214**. The body **210** has a through bore **216** to accommodate a fitting **218** on the end of the cutting blade **62**.

The fitting **218** has a cylindrical body **220** with an annular undercut **222**. With the fitting **218** directed into the bore **216**, the undercut **222** aligns with a bore **224** through the adaptor body **210**, which receives a locking screw **226**. By directing the screw **226** into the bore **224** and tightening the screw **226**, the adaptor **208** can be substantially fixed relative to the cutting blade **62**.

As an alternative, the undercut **222** can be eliminated. A flattened or concave cavity can be formed at a location as indicated by the "X's" in FIG. **21**, against which the screw **226** can be tightened.

The adaptor **208**, with the cutting blade **62** attached thereto, is maintained in the receptacle **206** by a cover plate **228**, which is held in place by fasteners **230** and overlies the adaptor **208**. The cover plate **228** has a central opening **232** to loosely receive the cutting blade **62**.

Preferably, the receptacle **206** has a shape that is complementary to the adaptor **208** and is dimensioned slightly larger than the adaptor **208** to allow the adaptor **208** to shift within the receptacle **206** transversely to the axis **102**. This allows the cutting blade **62** to self center in a guide bushing **234** (See also FIGS. **15** and **16**) on a guide subassembly on the frame **52**, above the support surface **54**. The guide bushing **234** can be made from a non-lubricated, low friction material. The central axis **236** of each guide bushing **234** aligns with the central axis of an opening **82** to cause the cutting blades **62** to become accurately aligned with the openings **82**. This arrangement prevents binding and assures

that the cutting blades **62** can be directed into the openings **82** without any interference.

As seen in FIGS. **6–12**, The guide cases **140** are fixedly joined, each to the other, through a bracket **240**, secured to each of the guide cases **140** through fasteners **242**. The bracket **240** is part of a pressing assembly **243** including a pressing plate **244** with a pressing surface **246** which can be borne against a single piece or stacked pieces of sheet material **56** placed upon the support surface **54** during a punching operation. The pressing assembly **243** includes vertically extending guide rods **248** fixedly attached to the pressing plate **244** and each having an upper end **250** which is slidable guidingly vertically relative to the bracket **240**. A retainer **252** on the upper end **250** of each guide rod **248** limits upward sliding movement of the bracket **240** relative to the guide rods **248**. A coil spring **254** surrounds each guide rod **248** and acts between the bracket **240** and pressing plate **244**.

As the handle **78** is moved from the normal to the actuated position, the blade moving assemblies **96** are driven downwardly. As this occurs, as seen in FIG. **11**, the bracket **240**, through the springs **254**, biasably urges the pressing plate **244** downwardly against the sheet material **56** upon the support surface **54**. Continued downward movement of the bracket **240**, as seen in FIG. **12**, compresses the springs **254** to thereby increase the holding force produced by the pressing surface **246** of the pressing plate **244** on the sheet material **56**. This firmly, biasably holds the sheet material **56** in a proper position for accurate hole punching. Once the punching operation is completed and the downward pressure on the handle **78** is released, the springs **254** drive the blade moving assemblies **96** upwardly to the first position. In so doing, the shaft **120** rotates so as to return the handle **78** from the actuated position to the normal position therefor.

The overall operation of the hole punching apparatus **50** will now be described. Initially, the hole punching apparatus **50** is plugged in to the power source **92**. The power switch **90** is moved form an off position to an on position. With the handle **78** in the normal position, the actuating element **116** is situated as in FIG. **7** to bear a pivoting switch lever **256** (FIG. **6**) upwardly under the force of the springs **254** so as to depress the button **112** on the switch **114** and thereby place the switch **114** in an open state. In this state, the conductive path from the power source **92** to the driving motor **84** is interrupted so that the driving motor **84** is deactivated. By moving the handle **78** from the normal position towards the actuated position, the shaft **120** rotates in the direction of the arrow **140**, causing the actuating element **116** to separate from the switch lever **256**, which pivots downwardly, allowing the button **112** to extend, thereby placing the switch **114** in an on state and forming a conductive path from the power source **92** to the driving motor **84** to activate the driving motor **84**. Upon activation of the motor **84**, rotation therefrom is imparted through the pulley **16**, the speed reducer **110**, and pulleys **108** to the shafts **98**, which rotate the blade holders **142** and the cutting blades **62** around the axis **102**. At the same time, the shaft **120** rotates the gears **118**, which drive the guide cases **146** downwardly, thereby moving the blade moving assemblies **96** from the first position of FIG. **7**, in which the cutting blades **62** are in the retracted position, to the second position of FIG. **6**, wherein the cutting blades **62** are in the cutting position. As the handle **78** is moved from the normal position towards the actuated position, the pressing assembly **243** moves downwardly, initially causing the pressing plate **244** to contact the sheet material **56** on the support surface **54** and ultimately to increase a captive force produced by the pressing plate **244** thereon. During the punching operation, the cut-outs **85** are separated from the sheet material **56** and driven upwardly into the cavities **152** by the projections **160**. Eventually, after repeated punching operations, the cavities **152** fill with cut-outs **85**, which then move through the passageways **168** through the guide cases **140** and blade holders **142** and are guided by the ramp surfaces **170** on the guide cases **140** into the receptacle **86** for accumulation. The removable container **88**, which defines at least a part of the receptacle **86**, can be separated from the remainder of the frame **52** to dispose of the cut-outs **85**.

In the event that the load on the drive motor **84** becomes excessive, the breaker **94** may be thrown to prevent damage to the drive motor **84**. The breaker **94** can be re-set after the condition causing the overload has been remedied. Once the punching operation has been completed, the handle **78** is released and is driven by the springs **254** back into the normal position therefor.

The hole punching apparatus **50** described is susceptible to many different variations without departing from the spirit of the invention. For example, in FIG. **23**, the mounting portion **202**, previously described, which has a cylindrical shape, is shown replaced by a square mounting portion **258** which functions in substantially the same manner as the mounting portion **202**.

The above-described cooperation between each cutting blade **62** and projection **160** can be realized whether or not the cutting blade **62** is rotating. Accordingly, the inventive concept can be used in a hole punching apparatus which uses a cutting blade **62** that moves in translation only i.e. that is not rotated.

The invention also affords the ability to change the configuration of the holes punched thereby, be it a change in diameter or shape. With the above-described arrangement, the cutting blade **62** and adaptor **208** can be readily removed and replaced by a different cutting blade which can be similarly held by the adaptor **208**. The bushing **234** can be replaced by a bushing which is complementary to the newly attached cutting blade. Since the openings **82** should closely accommodate the cutting blades **62**, openings **82** of different shape and diameter may be necessary. To facilitate this, the entire upper surface **54** may be defined by a separable layer **260**. Layers with appropriate openings may be interchanged. Alternatively, a removable insert such as that shown at **262** (FIG. **5**) can be used. The insert **262** defines only a part of the support surface **54**. By interchanging inserts **262**, changing of the dimension of the openings **82** through the support surface **54** can be more readily accomplished.

In another aspect of the invention, the projection **160** is defined on the insert **158** that is press fit to the frame **52** through the opening **82**. Each insert **158** can be removed from the opening **82** to allow replacement thereof with an insert having a different shape or dimension to accommodate the cutting blade **62** that is selected.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. A hole punching apparatus comprising:

a frame having surface for supporting a workpiece to be cut and a recess in said support surface;

a blade having a tubular cutting edge and a cavity with a diameter,

the blade having first and second ends with the cutting edge being at the first end of the blade,

the blade being rectilinearly movable relative to the frame between a retracted position and a cutting position, the blade in said cutting position residing in the recess;

a projection in said recess which moves into the blade cavity as the blade moves from the retracted position into the cutting position,

wherein the diameter of the cavity decreases from the cutting edge up to a first predetermined axial distance from the cutting edge towards the second end of the blade and increases from the first predetermined distance towards the second end of the blade,

wherein the projection extends into the cavity at least the predetermined axial distance from the cutting edge when said blades in the cutting position such that a cutout from said workplace is advanced past said decreased diameter portion of said cavity; and

a drive for rotating the cutting edge around a first axis as the blade moves from the retracted position into the cutting position.

2. The hole punching apparatus according to claim **1** wherein the frame defines a surface to support material on which a hole punching operation is to be performed, and further comprising a pressing assembly which is normally biasably urged away from the support surface, the pressing assembly having a pressing surface which is moved towards the support surface to captively hold material against the support surface as an incident of the blade moving from the retracted position into the cutting position.

3. The hole punching apparatus according to claim **1** wherein the hole punching apparatus comprises a second blade having a second tubular cutting edge and second cavity, the second blade being movable relative to the frame between a retracted position and a cutting position, and a second projection on the frame which moves into the second cavity as the second blade moves from the retracted position for the second blade into the cutting position for the second blade, wherein the second blade is movable from the retracted position for the second blade into the cutting position for the second blade as an incident of the handle moving from the normal position into the actuated position.

4. The hole punching apparatus according to claim **1** wherein the cavity has first and second ends spaced along the first axis, the cutting edge is at the first end of the cavity, the cavity has a diameter taken transversely to the first axis, and the diameter of the cavity is non-uniform along the first axis.

5. The hole punching apparatus according to claim **4** wherein the projection extends into the cavity further than the predetermined axial distance from the cutting edge.

6. The hole punching apparatus according to claim **1** further comprising a handle that is movable relative to the frame between a normal position and an actuated position, the blade being movable from the retracted position into the cutting position as an incident of the handle moving from the normal position into the actuated position.

7. The hole punching apparatus according to claim **6** wherein the handle is pivotable about an axis as the handle moves between the normal and actuated positions.

8. The hole punching apparatus according to claim **6** further comprising a drive motor for rotating the cutting edge around a first axis as the blade moves from the retracted position toward the cutting position and a switch that is placeable selectively in a) an on state to cause activation of the drive motor and b) an off state to cause deactivation of the drive motor, wherein the switch is moved from the off state into the on state as an incident of the handle moving from the normal position into the actuated position.

9. The hole punching apparatus according to claim **1** further comprising a blade moving assembly and an adaptor for connecting the blade to the blade moving assembly, the blade moving assembly comprising a blade holder and a guide case, the blade moving assembly being translatable substantially parallel to the first axis between first and second positions as an incident of which the blade moves from the retracted position into the cutting position wherein the blade holder is rotatable relative to the guide case around the first axis.

10. The hole punching apparatus according to claim **9** wherein the blade is loosely held by the blade moving assembly so that the blade can be shifted at least transversely to the first axis relative to the blade moving assembly.

11. The hole punching apparatus according to claim **10** wherein there is a guide bushing on the frame which guides the blade as the blade moves from the retracted position into the cutting position.

12. The hole punching apparatus according to claim **9** further comprising a handle that is movable relative to the frame between a normal position and an actuated position, the blade moving assembly being movable from the first position into the second position as an incident of the handle moving from the normal position into the actuated position, the hole punching apparatus further comprising a first set of gear teeth which are movable by the handle and a second set of gear teeth on the guide case which cooperate with the first set of gear teeth to cause the blade moving assembly to move from the first position into the second position as an incident of the handle moving from the normal position into the actuated position.

13. The hole punching apparatus according to claim **12** wherein the handle is pivotable about a second axis as the handle moves between the normal and actuated positions and the first set of gear teeth pivot with the handle about the second axis.

14. The hole punching apparatus according to claim **13** further comprising a switch that is placeable selectively in a) an on state to cause activation of the drive and b) an off state to cause deactivation of the drive and an actuator element, the actuator element following pivoting movement of the handle and causing the switch to be changed from the off state into the on state as an incident of the handle moving from the normal position into the actuated position.

15. The hole punching apparatus according to claim **9** wherein the drive comprises a shaft which is rotatable around the first axis and the shaft is rotatable relative to the guide case around the first axis.

16. The hole punching apparatus according to claim **15** wherein the shaft is keyed to the blade holder so that the shaft drives the blade holder in rotation around the first axis.

17. The hole punching apparatus according to claim **9** wherein there is a receptacle for material punched out by the hole punching apparatus on the frame, there is a passageway defined through the blade holder and guide case, and material punched out by the hole punching apparatus is capable of communicating through the blade cavity to the passageway and through the passageway to the receptacle for accumulation therein.

18. The hole punching apparatus according to claim **1** wherein the blade is movable substantially parallel to the first axis between the retracted and cutting positions.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,540,451 B1
DATED : April 1, 2003
INVENTOR(S) : Makoto Mori

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Insert Item:
-- [30] **Foreign Application Priority Data**

Japanese Application No. 10-290514 filed October 13, 1998. --

Column 11,
Line 14, should read as follows: -- when said blade is in the cutting position such that a --

Signed and Sealed this

Sixteenth Day of December, 2003

JAMES E. ROGAN
Director of the United States Patent and Trademark Office